

## Chapter 6

# Wisconsin's Ecological Features and Opportunities for Management



## Where to Find the Publication

*The Ecological Landscapes of Wisconsin* publication is available online, in CD format, and in limited quantities as a hard copy. Individual chapters are available for download in PDF format through the Wisconsin DNR website (<http://dnr.wi.gov/>, keyword "landscapes"). The introductory chapters (Part 1) and supporting materials (Part 3) should be downloaded along with individual ecological landscape chapters in Part 2 to aid in understanding and using the ecological landscape chapters. In addition to containing the full chapter of each ecological landscape, the website highlights key information such as the ecological landscape at a glance, Species of Greatest Conservation Need, natural community management opportunities, general management opportunities, and ecological landscape and Landtype Association maps (Appendix K of each ecological landscape chapter). These web pages are meant to be dynamic and were designed to work in close association with materials from the Wisconsin Wildlife Action Plan as well as with information on Wisconsin's natural communities from the Wisconsin Natural Heritage Inventory Program.

If you have a need for a CD or paper copy of this book, you may request one from Dreux Watermolen, Wisconsin Department of Natural Resources, P.O. Box 7921, Madison, WI 53707.



Photos (L to R): Common Loon, photo by Ryan Brady; black bear, photo by Herbert Lange; Greater Prairie-chicken, photo courtesy of U.S. Fish and Wildlife Service; Canada Warbler, photo by Brian Collins; wild lupine, photo by Brian Collins.

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# Wisconsin's Ecological Features and Opportunities for Management

As described in this chapter, “ecological features” refer to interactive groupings of landforms, waterbodies, natural communities, and other significant habitats for native plants and animals. These usually occur at large scales, extend beyond the boundaries of individual ecological landscapes, and some cross state (e.g., the North Woods) or international (e.g., the *Niagara Escarpment*) boundaries. This does not in any way diminish the importance or value of individual species, natural communities, habitats, or the 16 ecological landscapes discussed in detail elsewhere in this publication, but additional consideration of ecological features at broad *scales* provides regional, continental, and global perspectives and helps to identify management priorities and opportunities that are especially important to recognize and take advantage of in Wisconsin. Wisconsin’s ecological features include distinctive *mosaics* of natural communities, other terrestrial and aquatic habitats for native plants and animals, and ecosystem components such as landforms, bedrock and surficial geology, and soils.

The ecological features described below can be used as a framework for planning at large scales and to help identify management opportunities that are especially important to recognize and take advantage of in Wisconsin compared with other places. These descriptions can be used to better ensure that co-occurring and interacting mosaics of natural communities are managed compatibly and with their continental distribution and long-term viability in mind. To learn more about these ecological features, see the 16 ecological landscape chapters.

Since ecosystem management operates at multiple scales, this book identifies important ecological features and management opportunities at four different scales: global (continental), regional (state or multi-state), ecological landscape, and local (site, property, or project). Some users will want or need to examine important ecological features at broad scales; others may want to know the most important ecological features and best management opportunities for the

ecological landscape in which they live and work. Opportunities for management of natural communities are provided in Appendix E, “Opportunities for Sustaining Natural Communities in Each Ecological Landscape” in Part 3 of the book (“Supporting Materials”). Here, natural community types are listed according to their opportunity to be maintained within each ecological landscape. Finally, opportunities are sometimes mentioned at the property, project, or local site level in various locations throughout the book, especially in the ecological landscape chapters.

## Key Ecological Features in Wisconsin

This section describes some of the ecological features that are especially well represented in Wisconsin from a continental perspective. Wisconsin contains a diverse array of ecological features that make it an ecologically important place, continentally and globally. The *Tension Zone* is an ecoclimatic band that crosses the state from northwest to southeast, separating the prairie-savanna-hardwood forest ecosystems of the south and west from the mixed coniferous-deciduous forest ecosystems of the north and east. Diverse, sometimes distinctive, species mixes occur within and along the Tension Zone.

Many species reach their natural range limits in Wisconsin because various environmental factors limit their geographical distribution in the state. In addition to those species reaching their range limits at the Tension Zone, dominant species such as American beech (*Fagus grandifolia*) and eastern hemlock (*Tsuga canadensis*) reach their westernmost range limits in Wisconsin. Some prairie species are at their northern or eastern range margins here, and some boreal species reach their southern range extremities and may be good candidates to monitor for sensitivity to climate and land use changes.

Terms highlighted in green are found in the glossary in Part 3 of the book (“Supporting Materials”). Naming conventions are described in Part 1 in the Introduction to the book. Data used and limitation of the data can be found in Appendix C, “Data Sources Used in the Book,” in Part 3.

Wisconsin has an exceptional representation of glacial features, including moraines, till plains, outwash plains and terraces, drumlin fields, eskers, *ice-walled lake plains*, glacial lakebeds, buried forests, *kettle lakes*, *kames*, and glacial *tunnel channels*. Wisconsin also has an abundance and high diversity of freshwater resources, including major rivers, many streams, thousands of lakes, springs, and seeps, and abundant groundwater storage. Millions of acres of wetlands play key ecological and socio-economic roles in maintaining both the quantity and quality of these water resources. Most of the wetlands and lakes and many of the streams are representatives of Wisconsin's glacial legacy.

The Upper Midwest, including most of Wisconsin, is one of the relatively few places in the world with a moderate climate and well-developed, nutrient-rich soils of recent glacial origin. Glaciation releases mineral nutrients and creates soils with ideal texture and nutrient status for the production of many agricultural crops. Natural communities associated with the soils derived from glacial tills and wind-borne loess deposits include hardwood forests, savannas, and tallgrass prairies. Wetlands in most of southern Wisconsin, especially in the glaciated areas and along the major rivers, tend to be highly biologically productive (the acid peatlands of central Wisconsin are exceptions to this). Warmwater rivers and streams are capable of supporting diverse assemblages of fish, herptiles, and invertebrates.

The productivity of many portions of the state has resulted in significant levels of resource extraction. The widespread conversion of natural vegetation to cropland and pasture has been the norm in much of southern Wisconsin and in some areas north of the Tension Zone such as the Forest Transition Ecological Landscape.

Wisconsin also includes roughly three quarters of the Driftless Area (also referred to as the Paleozoic Plateau), a landscape unique in that it is entirely surrounded by lands showing evidence of recent glaciation. Though not covered by ice sheets in recent times, many parts of the Driftless Area did receive air or water-borne deposition of glacial materials from other parts of the continent. High agricultural productivity is strongly associated with the loess deposits of southwestern Wisconsin (see the "Surficial Deposits" map in Appendix G, "State-wide Maps" in Part 3 of the book) though these soils can be highly erodible.

The ecological features prominent in Wisconsin provide the physical and ecological underpinnings of the state's distinctive ecology. Outstanding ecological features discussed below include the Driftless Area; the Great Lakes; the North Woods; glacial outwash plains, lakebeds, and associated natural communities and waterbodies; the outstanding array of glacial landforms and related natural communities (many of them now rare) in the southeast; and the Niagara Escarpment. Large rivers systems, their complex floodplains and corridors, the high biodiversity these ecosystems support, and concentrations of glacial lakes are also especially well represented in Wisconsin, but these have been folded into some of the other ecological features. These are important enough from regional perspectives that they could also be treated separately, but there is quite a bit of overlap with the ecological features. For example, the Wisconsin River links the North Woods, the Central Sands region, and the Driftless Area and, in doing this, crosses several ecological landscapes. The St. Croix River system originates in the Northwest Sands, passes through the Northwest Lowlands, Forest Transition, and Western Prairie ecological landscapes, and flows into the Mississippi River at the northern edge of the Driftless Area.

### Driftless Area

The Driftless Area is a unique unglaciated landscape that encompasses much of southern and western Wisconsin, along with much smaller portions of Minnesota, Iowa, and Illinois (Figure 6.1). Approximately 75% of the Driftless Area is within Wisconsin. This is our oldest land surface, with a well-developed *dendritic drainage system*, numerous bedrock outcroppings, and a complete absence of the characteristic glacial landforms and related features so striking elsewhere in Wisconsin. Land use patterns are very different here than they are in the rest of Wisconsin.



**Figure 6.1.** The Driftless Area (outlined in red) refers to those parts of southwestern Wisconsin and adjacent Illinois, Iowa, and Minnesota that were not covered by the Quaternary glaciers. In Wisconsin, the Driftless Area includes all or most of the Southwest Savanna and Western Coulees and Ridges ecological landscapes. Driftless Area boundary courtesy of the Driftless Area Initiative. Basemap © ESRI. All rights reserved.

**Rare species** are comparatively numerous here, owing to the diversity and quality of habitats present as well as limitations placed on land use by topography and underlying bedrock. Among the rarities are species endemic to the Upper Midwest and **periglacial relicts**, species that have persisted in rare, geographically restricted, and highly unusual habitats found nowhere else in the Midwest.

Important ecological attributes of the Driftless Area include the following:

- Landforms and drainage patterns are markedly different here than in any part of the glaciated Upper Midwest.



*Extreme differences in land use and intensity surround major Driftless Area rivers. Here, the floodplain contains extensive wetlands, and the steep bluffs are heavily forested apart from scattered prairie and savanna remnants. The broad terraces between these are developed and now occupied by agricultural fields, housing, roads, railways, and power lines; the oak savannas and sand prairies that were formerly common here are now rare throughout the Midwest. Photo © George Howe, Mississippi Valley Conservancy.*



*Wisconsin's glacial history strongly influences patterns of vegetation and land use. The left photo shows heavily forested areas occupying steep, rocky slopes of the (unglaciated) Driftless Area. The forest patches are limited in size and dissected by agriculture on the more level areas, a pattern representative of many parts of the Western Coulees and Ridges Ecological Landscape. Photo courtesy of U.S. Fish and Wildlife Service – Midwest Region. The right photo is from the formerly glaciated Southeast Glacial Plains. This landscape's level topography and fertile soils have resulted in more widespread and intensive agriculture and more severe fragmentation of natural communities. Remaining patches are often very small, isolated, and completely surrounded by croplands. Photo by Eric Epstein, Wisconsin DNR.*

- Large rivers with complex floodplains, extensive sand terraces, riverine lakes, and exceptionally high aquatic biodiversity are well represented here and are of continental significance.
- The upper Mississippi River valley has been highly altered by navigation dams, agriculture, transportation routes (e.g., railways and highways), and several major urban centers, but the river retains high aquatic biodiversity, and the valley remains one of the continent's major flyways for migratory birds. For example, a large portion of the continental population of migrating Tundra Swans (*Cygnus columbianus*) and Canvasbacks (*Aythya valisineria*) use the upper Mississippi River valley.
- The greatest acreage of deciduous forest remaining south of the Tension Zone is concentrated in the Driftless Area (see Figure 2.20 in the "Southern Forest Communities" section of Chapter 2, "Assessment of Current Conditions"). Oak-dominated dry and dry-mesic forests, mesic maple-basswood forests, and bottomland hardwoods are important forest types in terms of their ecological significance, socioeconomic values, and sheer abundance.
- Large blocks of relatively unfragmented forest occur in the Baraboo Hills, the upper Kickapoo River valley, and along the Wisconsin, Chippewa, and Black rivers in addition to several other Driftless Area locations. These sites provide **critical habitat** for species that cannot persist in the severely altered and fragmented environments that are now so characteristic of much of southern Wisconsin. These large, relatively intact sites are especially vital for those species whose ranges do not extend into northern Wisconsin, though much more extensive forests occur there. The potential to manage for missing or diminished forest conditions (including large patches and missing



structural features such as those associated with *old-growth forests*) is excellent, especially on mesic to dry-mesic upland sites and on wetter sites within the floodplains of the larger rivers and streams.

- Tallgrass prairie and oak savanna remnants embedded within extensive surrogate grasslands offer high restoration and management potential for these continentally decimated ecosystems.
- One of the Upper Midwest's greatest concentrations of (dry) bluff prairies is here, and these unique native grasslands are often associated with fire-dependent savanna, woodland, and dry forest communities.
- Seepages, springs, and coldwater streams are numerous in some parts of the Driftless Area.
- Bedrock features such as cliffs, caves, and *talus slopes* are more abundant and widespread here than in any other region in Wisconsin.
- *Relict* stands of northern conifers are locally prominent, along with natural communities that depend on a very narrow range of specific geologic conditions and occur nowhere else, such as Algific Talus Slopes.
- Caves and abandoned mines provide habitat for regionally significant numbers of roosting and hibernating bats.
- Overall, the Driftless Area supports high biodiversity values, including natural communities and species that do not occur or are no longer found in abundance elsewhere.

Ecological landscapes of the Driftless Area include the Western Coulees and Ridges and Southwest Savanna. Large parts of the Central Sand Plains Ecological Landscape were also unglaciated; however, that ecological landscape was strongly influenced by the glaciation to the north and has very different topography, soils, hydrology, and vegetation than the Driftless Area. Much of the Central Sand Plains was occupied by a huge *proglacial* waterbody, Glacial Lake Wisconsin (see the map of former Glacial Lake Wisconsin in Chapter 10, "Central Sand Plains Ecological Landscape"). For additional information on Glacial Lake Wisconsin, see Clayton and Attig (1989).

## Great Lakes

Two of earth's largest freshwater lakes border Wisconsin. Lake Superior, the largest freshwater lake on the planet by surface area, adjoins northwestern Wisconsin. Compared with the other Great Lakes, Superior is larger, deeper, holds the most water, is less developed, less disturbed, and supports extensive areas of intact shoreline and deepwater environments.

Lake Michigan forms Wisconsin's "east coast," the most heavily developed and populated part of the state. The lake's biota and many adjoining habitats have been highly unstable over the past half-century owing to habitat destruction or degradation, pollution, overfishing, and sometimes devastating introductions of nonnative invasive species.

Both lakes support important rookeries of colonial birds such as gulls, terns, pelicans, and cormorants. The colonies are most often located on islands, both natural and constructed, away from the mainland. Shoreline habitats restricted to the margins of the Great Lakes may provide *refugia* for some species sensitive to climate change.

## Lake Superior

The following key ecological features are associated with Lake Superior:

- One of the greatest concentrations of intact freshwater estuaries on the Great Lakes occurs on southwestern Lake Superior. Complex vegetation mosaics occur in the estuaries and are not repeated at inland sites or in the more developed or degraded areas of the Lake Superior coast.
- A variety of wind, wave, and current-created *sandscapes* are found here; these provide the setting for rare natural communities such as Great Lakes Beach, Great Lakes Dune, Interdunal Wetland, Great Lakes Barrens, old-growth hemlock-hardwood forests, and coastal pine forests.
- The Boreal "clay plain" Forest is a natural community restricted to the heavy red clay soils occurring in a narrow band along southern and western Lake Superior.



Interdunal wetland with pool. Stockton Island Tombolo, Apostle Islands National Lakeshore, Ashland County. Photo by Eric Epstein, Wisconsin DNR.

- The Apostle Islands include unique geological features such as sculpted sandstone cliffs and sandscapes, undisturbed wetland complexes, and “*maritime*” forests, which include old-growth stands.
- Rich mosaics of forest communities associated with the larger rivers that have cut through deep red clay deposits in route to Lake Superior include Wisconsin's northernmost stands of floodplain forest, alluvial terraces supporting floristically rich maple-basswood forests that host many vascular plant species far north of their previously known range limits, and mesic to dry-mesic boreal conifer-hardwood forests.
- Extensive wetlands on the poorly drained red clays near the southwestern corner of Lake Superior support unique assemblages of vascular plants that include many rarities. Such habitats are highly localized in the state and region and are most extensive in northwestern Wisconsin.
- Major migratory bird concentration areas are associated with sandscapes and lagoons, the Apostle Islands archipelago, and the western end of Lake Superior.
- Because of the large spring and fall concentrations of migratory birds and the many rare species nesting and wintering in the vicinity of the shoreline, any wind development proposed for the Lake Superior region needs to be evaluated carefully.
- Important commercial and sport fisheries occur here.

Wisconsin's only ecological landscape bordering Lake Superior is the Superior Coastal Plain.

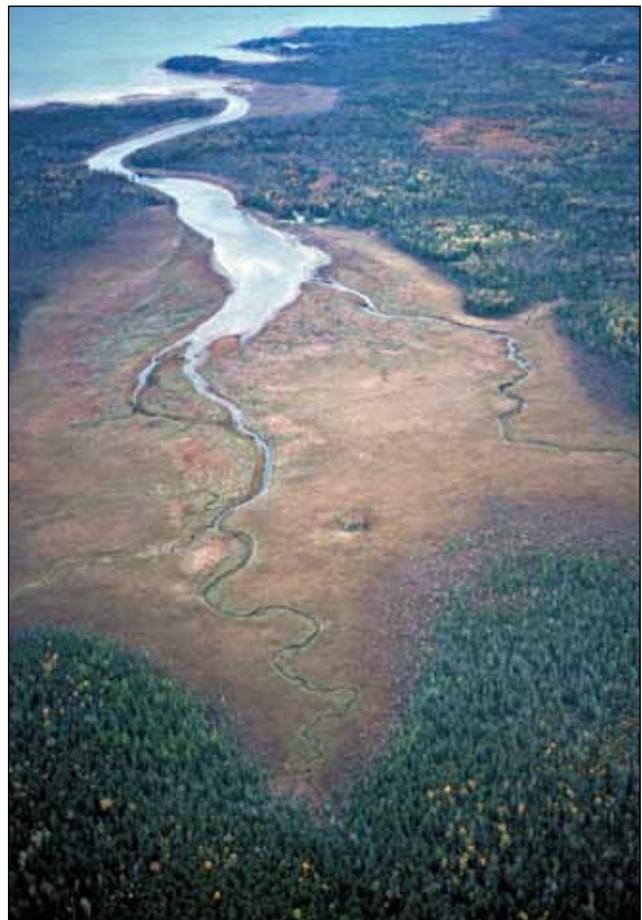
## Lake Michigan

The following key ecological features are associated with Lake Michigan:

- Coastal ridge-and-swale landforms occur along Lake Michigan from the southeastern corner of the state, where Wisconsin's only lakeplain prairie complex occurs, to the Door Peninsula, where the swales support marsh, wet meadow, fen, and conifer swamp vegetation alternating with sandy ridges forested with pines, hemlock-hardwoods, or boreal conifers.
- Extensive, nearly level exposures of dolomite occur along the northeastern Door Peninsula and in the Grand Traverse Islands. These feature alkaline rockshore and cobble beach communities, alkaline meadows, and numerous rare species populations.
- The Niagara Escarpment is the steep face of a Silurian dolomite bedrock feature that is exposed as cliffs and talus slopes along the eastern shore of Green Bay (this is the same bedrock that forms horizontal pavements and numerous ledges elsewhere on the Door Peninsula and in the Grand Traverse Islands). Numerous rare plants

and some globally rare terrestrial snails are known from escarpment habitats. The Niagara Escarpment continues north and east through the Grand Traverse Islands archipelago to New England.

- Freshwater estuaries and other coastal wetlands occur along the Lake Michigan shore, such as the Mink River Estuary (Door County), the Kewaunee River Marsh (Kewaunee County), and Point Beach State Forest (Manitowoc County).
- Lake Michigan's beach and dune complexes support plants and animals endemic to Great Lakes coastal habitats.
- The extensive marshes and wet meadows along the west shore of Green Bay provide critical habitat for fish, birds, and other organisms.
- Important sport and, to a lesser extent, commercial fisheries still occur here.



*The Mink River Estuary is a Great Lakes coastal wetland complex of exceptional quality that contains a diverse mosaic of natural communities including Hardwater Springs, Emergent Marsh, Northern Sedge Meadow, Great Lakes Alkaline Rockshore, northern white-cedar-dominated Northern Wet-mesic Forest, and Northern Mesic Forest. Many rare species have been documented here. Photo by Eric Epstein, Wisconsin DNR.*

- Use of Lake Michigan waters and coastal habitats by migratory, wintering, and nesting birds is major. The coastline of Lake Michigan trends north-south, making it a natural “leading line” followed by many migrating birds.
- Industrial wind development is being considered for the open waters of Lake Michigan and needs to be studied and evaluated carefully.

Ecological landscapes along Lake Michigan include the Northern Lake Michigan Coastal, Central Lake Michigan Coastal, and Southern Lake Michigan Coastal.

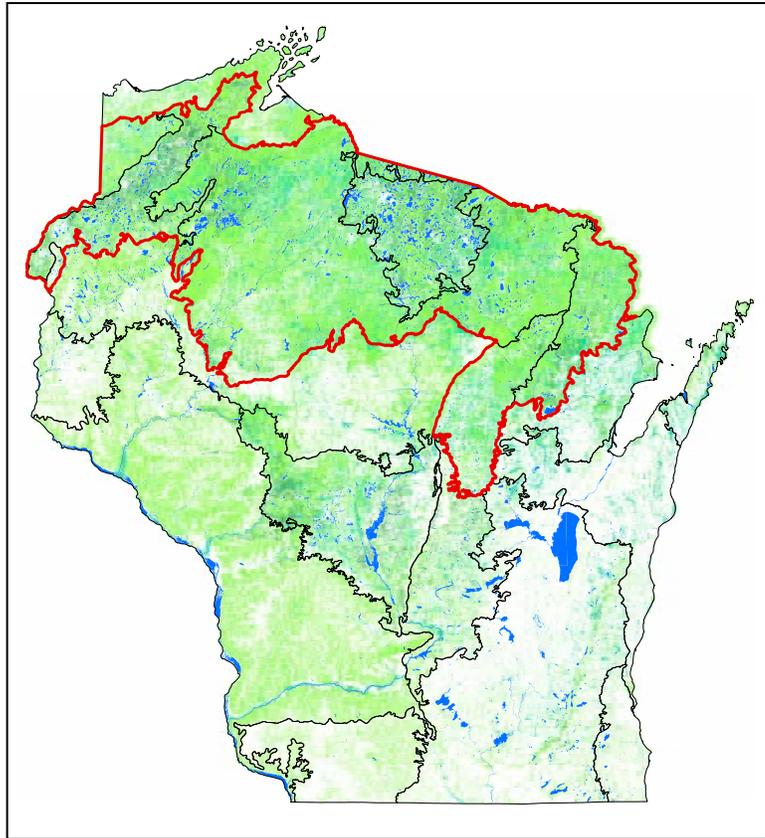
## North Woods

In the western Great Lakes region, vast hardwood-conifer forests persist across portions of Michigan, Minnesota, Ontario, and Wisconsin. Thousands of lakes, streams, and wetlands are embedded within this forest *matrix*, which is largely responsible for the intact nature of many watersheds, the generally high water quality, and the existence of numerous aquatic species relatively intolerant of habitat degradation. Fewer wetlands have been drained or filled here compared with areas to the south where the practice of intensive agriculture is widespread and human populations are higher.

This is one of relatively few areas in the state in which natural vegetation is still overwhelmingly dominant throughout (Figure 6.2), and the diverse group of natural communities, the scale at which they occur, and their proximity to one another have created interior forest conditions at large scales that support viable populations of rare and common species. See Howe et al. (1996) for information on the significance of these forests to breeding birds.

Important ecological features of Wisconsin’s North Woods include the following:

- A matrix forest of mesic hardwoods, aspen-birch, and hemlock-hardwoods exists across almost the entire region.
- There is less permanent habitat fragmentation, isolation, and development compared with other areas.
- Some of the places representing the best opportunities to manage for and perpetuate interior forest conditions in the state include the Penokee Range (also referred to as the Penokee-Gogebic Range when Michigan’s portion of this geological feature is included),



**Figure 6.2.** The areas outlined in red on the map as “the North Woods” are now heavily forested. The ecological landscapes making up the North Woods include the North Central Forest, Northern Highland, Northeast Sands, Northwest Lowlands, Northwest Sands, parts of the Superior Coastal Plain, and Forest Transition ecological landscapes.

the Blue Hills (Rusk and Barron counties), the Headwaters Wilderness Area (Forest County), the *Winegar Moraine* (Vilas County, especially), and parts of the adjoining Northern Highland Ecological Landscape. Especially important properties with the capacity to support interior forest conditions at large scales include the Chequamegon-Nicolet National Forest, the Northern Highland-American Legion State Forest, and the Flambeau River State Forest.

- The potential to manage for diminished or missing old-growth forest developmental stages and large forest patches is exceptional and applies to many upland and lowland forest communities.
- Large and potentially viable populations of many native plants and animals occur here, including continental source populations of birds (Howe et al. 1996).
- One of the highest diversities of breeding birds recorded for North America occurs in this complex of diverse and extensive forests (Green 1995).
- The headwaters areas for many of Wisconsin’s largest rivers and streams occur here. Watersheds remain heavily forested, and development is somewhat less than in other parts of the state. Among the important rivers and large streams originating here are the Wisconsin,

Chippewa, Flambeau, Black, Bad, Wolf, Pine, Popple, and Peshtigo. Numerous small streams also begin in the heavily forested parts of northern Wisconsin.

- This area contains a large number of freshwater lakes and associated biota, including charismatic megafauna such as Bald Eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), Common Loon (*Gavia immer*), Trumpeter Swan (*Cygnus buccinator*), black bear (*Ursus americanus*), gray wolf (*Canis lupus*), muskellunge (*Esox masquinongy*), and walleye (*Sander vitreus*).
- The Northern Highland Ecological Landscape is centered on a large glacial outwash landform surrounded by moraines and till plains. The Northern Highland Ecological Landscape contains one of the Upper Midwest's

greatest concentrations of inland lakes and offers the best potential in Wisconsin (and perhaps elsewhere) to manage at large scales for dry-mesic forests dominated by eastern white pine and red pine (*Pinus strobus* and *P. resinosa*).

- The wetlands embedded within the north's extensive forests include a diverse representation of conifer swamps, hardwood swamps, bogs, fens, sedge meadows and marshes. Some of these wetlands encompass thousands of acres, and many are in good condition.

Ecological landscapes making up the North Woods are the North Central Forest, Northern Highland, and portions of the Forest Transition and Northeast Sands. The Northwest Lowlands is separated from the matrix northern forests by the sandy, dry, and more open Northwest Sands Ecological Landscape, but the Northwest Lowlands is contiguous with the most heavily forested portions of northern Minnesota. (Wisconsin's northernmost ecological landscape, the Superior Coastal Plain, is significantly fragmented by agricultural lands and other developments.)



Canada Warbler (*Cardellina canadensis*, listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List), one of many bird species that breed in northern Wisconsin, is associated with extensive, structurally complex forests (Epstein 2006). Photo by Brian Collins.



Intact forested watershed in Vilas County with lakes, a spring pond, northern sedge meadow, and extensive mixed pine/hardwood forest. Photo by Eric Epstein, Wisconsin DNR.

## Glacial Outwash Plains and Glacial Lakebeds

Sandy outwash plains and glacial lakebeds are extensive and concentrated in northwestern, north central, northeastern, and central Wisconsin (Figure 6.3). In these areas, xeric forest and barrens were historically abundant, and the vegetation consisted mostly of mixtures of pine and oak forests, barrens, and scattered, sometimes extensive, wetlands. Some of the wetlands in these sandy regions are among the largest in the state, especially in the Central Sand Plains, Northern Highland, Northeast Sands, and Northwest Sands ecological landscapes.

Bedrock outcroppings are locally prominent in some areas. These are mostly Paleozoic sandstones in central Wisconsin and Precambrian granites in the northeast. These bedrock features provide critical habitat for specialized plants and animals. In the Northwest Sands and Northern Highland ecological landscapes, the bedrock is buried beneath deep deposits of outwash sands.

These extensive sandy regions are well represented and extensive within Wisconsin, making it particularly important to take advantage of the management opportunities available here. Development of property management plans that will conserve, increase, and connect remnant barrens vegetation while managing surrounding xeric forests of jack pine (*Pinus banksiana*), **scrub oak** (oaks [*Quercus* spp.] of small stature on nutrient-poor sites), or even some plantation-grown red pine could be designed and implemented to increase the effective area of the open habitats and reduce remnant barrens isolation. It would also reduce hard (high contrast) edges and restore some of the missing structural and patch size variability that was historically present in barrens ecosystems.



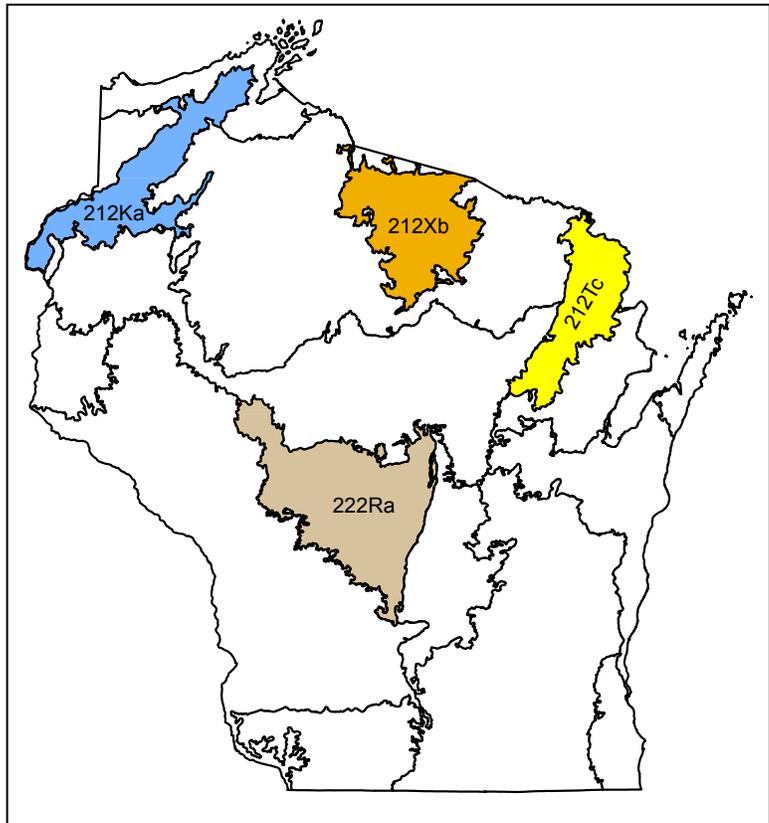
Lupine (*Lupinus perennis*), a characteristic barrens species and the only larval host plant for the globally rare Karner blue butterfly. Photo by Brian Collins.

Important ecological features include the following:

- The vast majority of the upland vegetation in these areas was fire adapted and, to some degree, fire dependent, though the fire disturbance regimes varied spatially, temporally, and in terms of severity, even within specific landscapes.
- Xeric forests of pine and oak, and especially the now globally rare Pine Barrens and Oak Barrens communities, were the dominant upland vegetation types. Some areas that were the most open in the mid-1800s, such as parts of central Wisconsin, now support very dense forests, while some formerly heavily forested areas are more open. This is primarily due to widespread implementation of fire suppression policies and the conversion of some historically forested lands to agricultural uses.
- Globally rare species such as the Karner blue butterfly (*Lycaeides melissa samuelis*) and Kirtland's Warbler (*Setophaga kirtlandii*, listed as *Dendroica kirtlandii* on the Wisconsin Natural Heritage Working List; WDNR 2009) are dependent on the xeric forest and barrens habitats that are most abundant, best developed, and offer the best long-term management opportunities in these sandy landscapes.
- The largest barrens management projects and opportunities are in northwestern Wisconsin; these are the last stronghold of area-sensitive, barrens-dependent species such as the Sharp-tailed Grouse (*Tympanuchus phasianellus*).

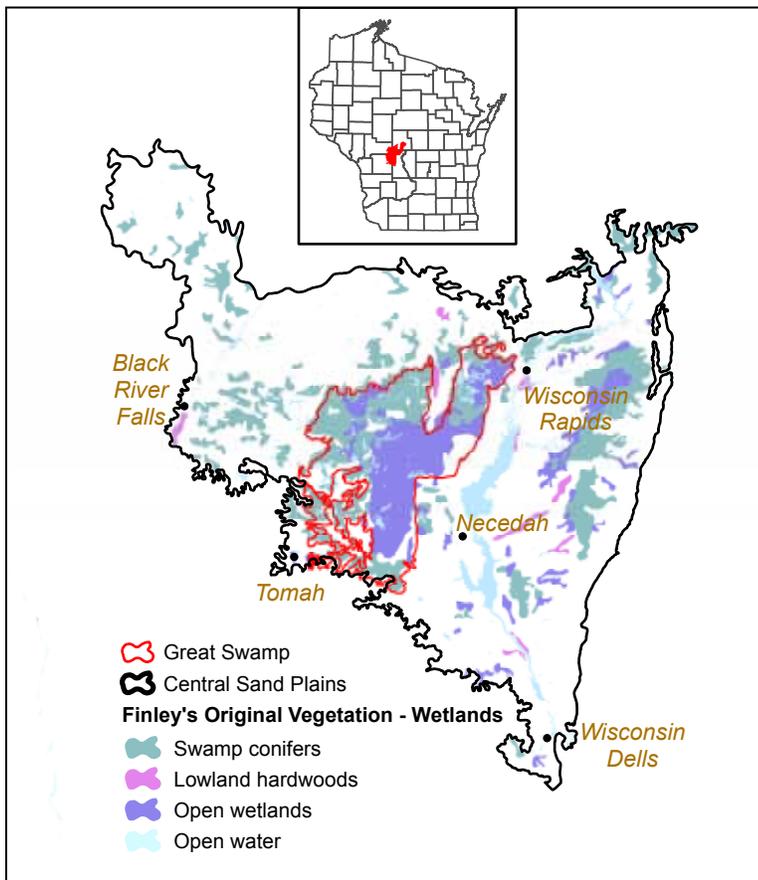


A scene typical of many barrens in the Central Sand Plains and Northeast Sands ecological landscapes, where black oak (*Quercus velutina*) or northern pin oak (*Quercus ellipsoidalis*) are the primary tree species along with prairie herbs and patches of shrubs. Community structure (e.g., the amount of openness) varies with the type, intensity, and frequency of past disturbances. Photo by Thomas Meyer, Wisconsin DNR.



**Figure 6.3.** The highlighted ecoregions correspond to the Central Sand Plains, Northern Highland, Northeast Sands, and Northwest Sands ecological landscapes. Each of these regions contains extensive areas of sandy glacial outwash and/or sandy glacial lakebeds. Most of the terrestrial vegetation is adapted to periodic fire.

- Vast peatlands of sedge meadow, poor fen, bog, and conifer swamp are found within the sandy regions, especially the old glacial lakebeds. The “Great Swamp of Central Wisconsin” was the state’s largest wetland (Martin 1916, Clayton and Attig 1989, Eswin 1995; Figure 6.4). Though much of it has been ditched, diked, or otherwise altered, the remaining wetlands are extensive, and some of them support sensitive animals such as the Trumpeter Swan and Whooping Crane (*Grus americana*).
- Northwestern Wisconsin contains some of the Upper Midwest’s largest sedge meadows, which provide critical space for many area-sensitive species of open habitats.
- Areas of *pitted* (“*collapsed*”) *outwash* occur in northwestern and north central Wisconsin and contain numerous kettle lakes.
- Surrogate grasslands are abundant in central Wisconsin east of the Wisconsin River. Though these large open areas are the product of peatland drainage, land clearing, and other high impact disturbances to accommodate agricultural uses, they offer excellent management opportunities for area-sensitive grassland wildlife species such as the Greater Prairie-Chicken (*Tympanuchus cupido*), Upland Sandpiper (*Bartramia longicauda*), and Short-eared Owl (*Asio flammeus*).



**Figure 6.4.** The Great Swamp of Central Wisconsin. The most extensive area of contiguous wetlands in Wisconsin occupied poorly drained portions of the Central Sand Plains ecological landscape. Much of this swampy area was within the bed of now extinct Glacial Lake Wisconsin.

Ecological landscapes containing extensive sandy outwash plains and lakebeds include the Northwest Sands, Central Sand Plains, and Northeast Sands. (The Northern Highland Ecological Landscape also has these features, but was, and remains, more heavily forested than the others.)

## Glaciated Southeastern Wisconsin

While most of the Upper Midwest was glaciated, the topography of southeastern Wisconsin is especially notable because of its outstanding examples of glacial features such as moraines (including the interlobate Kettle Moraine, an interlobate glacial moraine), drumlins, kames, eskers, clusters of glacial lakes, large productive marshes, and rich soils (Paull and Paull 1977). All of these features were of glacial origin. This is also one of Wisconsin’s most severely fragmented, highly disturbed, and intensively developed ecological landscapes. Southeastern Wisconsin supports the highest density of humans in Wisconsin and the most development, and the area has been largely converted to agricultural, residential, and industrial uses. As a result, the region contains a high concentration of remnant natural communities, aquatic features, plants, and animals that are now rare. The more extensive areas that have not experienced heavy development are generally too wet, too dry, or too rough. Examples include large and highly productive wetlands such as those found within Horicon Marsh and the White River-Puchyan River wetland complex. The rugged Kettle Moraine runs southwest to northeast across this area and contains the largest area of lightly developed (now mostly forested) uplands in the entire region.

Apart from the Kettle Moraine and several of the largest wetlands (mentioned above), habitat fragmentation and ecosystem disturbances are widespread and severe. Water quality in many areas is poor due to urban or agricultural runoff, and groundwater withdrawals are negatively affecting wetlands and streams in some areas. Public ownership is limited, making partnerships with local governments, private conservation organizations, and concerned citizens absolutely essential if habitat loss and degradation are to be effectively addressed.

Important ecological features of southeastern Wisconsin include the following:

- A concentration of globally rare communities including tallgrass prairie, oak savanna, and fen occurs here, especially in the southern portion of the Kettle Moraine.
- Relatively large hardwood forest remnants in the Kettle Moraine provide virtually all of the available viable breeding habitat for area-sensitive, forest interior wildlife, especially birds. Most of these lands are within the Kettle Moraine State Forest, especially the Northern Unit. Large upland forest patches outside of the state forest boundaries are being rapidly subdivided and may lose many of their ecological values over the next several decades.
- Highly productive marshes are characteristic of this part of Wisconsin. Some of these are very large and provide essential habitat for numerous wetland species, especially waterbirds and herptiles.
- Development around lakes is high in this region, which contains Wisconsin's largest inland lake by surface area (Winnebago) and the deepest inland lake (Green). Significant clusters of lakes include the "Winnebago Pool" lakes (Poygan, Winneconne, and Butte des Morts), the Madison lakes, the lakes in northwestern Waukesha County, lakes in and around the Kettle Moraine, and lakes in the southeasternmost part of the region. Dams on several of the major rivers, such as the Fox and Rock, have created or enlarged lakes.
- **Marl lakes** are common here, and despite negative impacts on some waterbodies from land uses such as agriculture, shoreline development, and residential sprawl, water quality in some of these lakes has remained good, with a high diversity of aquatic plants, macroinvertebrates, and fishes, including some rare or otherwise sensitive species.



Vast emergent aquatic marshes bordering the lower Wolf River, Winnebago County. Photo by Eric Epstein, Wisconsin DNR.

- The corridor of the lower Wolf River is especially important because it is associated with the most extensive areas of bottomland hardwoods and some of the largest riverine marshes in southeastern Wisconsin. The lower Wolf and the adjacent Winnebago Pool lakes support a self-sustaining, continentally significant population of the globally rare lake sturgeon (*Acipenser fulvescens*).
- The more intact warmwater rivers and streams such as the Wolf, Bark, Milwaukee, Oconomowoc, White, and Mukwonago continue to support significant aquatic biodiversity and are often associated with valuable, often extensive wetland communities.

Ecological landscapes in glaciated southeastern Wisconsin include the Southeast Glacial Plains, Southern Lake Michigan Coastal, and Central Lake Michigan Coastal.

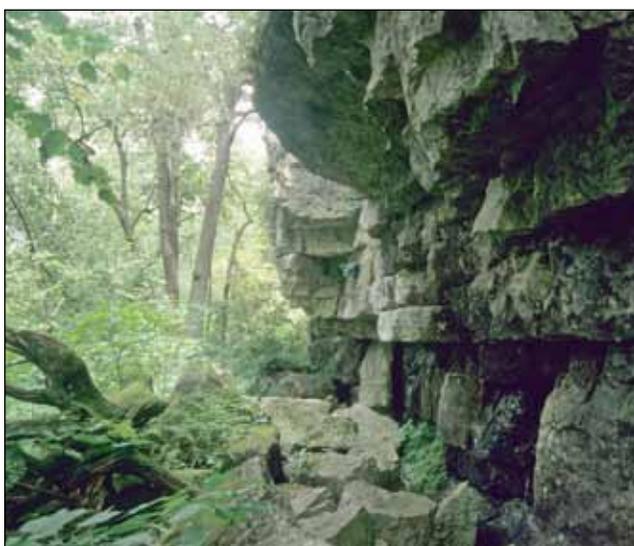
## Niagara Escarpment

The Niagara Escarpment is a linear bedrock feature composed of Silurian dolomite that extends from southeastern Wisconsin, through the west side of the Door Peninsula, north and east across northern lakes Michigan and Huron, all the way to New England. Wisconsin contains the southernmost extremity of this unique feature, which supports unusual fauna and flora. The southernmost portions of the Niagara Escarpment differ ecologically from those farther north because they occur south of the Tension Zone. The following are key features of the Niagara Escarpment:

- Populations of highly specialized terrestrial land snail species, some of them globally imperiled, inhabit the escarpment.
- A regionally significant bat hibernaculum occurs within an abandoned iron mine on the escarpment. The Wisconsin Natural Resources Board has formally listed four bat species (big brown bat [*Eptesicus fuscus*], little brown bat [*Myotis lucifugus*], eastern pipistrelle [*Perimyotis subflavus*], and northern long-eared bat [*Myotis septentrionalis*]) as threatened in Wisconsin because of the severe threat from "white-nose fungus" (*Geomyces destructans*), which has been linked to the deaths of over two million bats in the eastern U.S. since 2007 (D. Redell, Wisconsin DNR, personal communication).
- Some of Wisconsin's oldest documented trees have been found growing on the exposed bedrock of the escarpment. These include eastern red-cedar (*Juniperus virginiana*) to the south and northern white-cedar (*Thuja occidentalis*) to the north and east.
- Rare bedrock habitats of limited distribution in eastern Wisconsin that are strongly associated with the Niagara Escarpment include dry and moist cliffs, talus slopes, seeps, caves, alvar, and abandoned mines.



*The Niagara Escarpment is a prominent geological feature in eastern Wisconsin, where it provides habitat for rare plants and animals and ancient trees. The sedimentary bedrock is dolomite of Silurian age. Photo by Gary Fewless.*



*Moist (shaded) cliff of Silurian dolomite along the Oakfield Ledge portion of the Niagara Escarpment, Fond du Lac County. Photo by Emmet Judziewicz.*

- Bedrock exposures provide habitat for rare species besides terrestrial snails, such as specialized plants. Away from the escarpment, suitable habitats for these species are rare or absent in eastern Wisconsin.

Ecological landscapes hosting portions of the Niagara Escarpment include the Southeast Glacial Plains, Central Lake Michigan Coastal, and Northern Lake Michigan Coastal ecological landscapes.

## Summary of Ecological Features and Management Opportunities at the Ecological Landscape Scale

This section summarizes important ecological features and management opportunities at an ecological landscape scale. It is designed to allow the reader to explore ecological features and management opportunities for all 16 ecological landscapes (Figure 6.5) in one place, encouraging broad spatial and temporal perspectives on management opportunities in different parts of the state. Although many users will be most interested in information from the ecological landscape in which they work or reside, it is also useful to learn about ecological features and opportunities present in other ecological landscapes to take advantage of opportunities to collaborate on similar projects. This section can help users determine what makes their ecological landscape distinctive or unique and provides information that can help users coordinate with others who live and work in the same or different ecological landscapes. The ecological features listed in each ecological landscape imply that there are management opportunities for them there. Because this section is meant only as a starting place for highlighting major opportunities across all of the 16 ecological landscapes, the reader is encouraged to see the 16 individual ecological landscape chapters for the most comprehensive and detailed treatment of management opportunities.

### Central Lake Michigan Coastal

- Lake Michigan waters, important fisheries, shoreline processes, rare shoreline communities, and habitat for concentrations of migratory and wintering birds are especially important resources in the Central Lake Michigan Coastal Ecological Landscape.
- Great Lakes coastal wetlands and forests, ridge-and-swale complexes, beach and dune systems, interdunal wetlands, and clay seepage bluffs are among the important habitats associated with the Lake Michigan shore.
- Lower Green Bay is bordered by extensive marshes, contains islands that support colonial fish-eating birds, is used by large numbers of migratory and resident birds, and is an important spawning and nursery area for many fish.
- Populations of plants and animals endemic to Great Lakes shoreline habitats occur along the Lake Michigan shore.
- The Niagara Escarpment includes cliffs, talus slopes, alvar, and other regionally restricted bedrock-dependent habitats that are significant for globally rare land snails, rare plants, and ancient trees.



Forested floodplain of the lower Wolf River. This section in Outagamie County features oxbow lakes occupying abandoned meander channels. Photo by Eric Epstein, Wisconsin DNR.

- The lower Wolf River corridor features extensive floodplain forests, shrub swamps, meadows and marshes, which in turn support diverse assemblages of fish, birds, and other organisms. The lower Wolf is a major ecological feature and recreational resource.
- Though much of the interior of this ecological landscape is now devoted to agricultural and urban-industrial uses, there are several large hardwood-conifer swamps that provide significant habitat for native plants and animals.

## Central Sand Hills

- In the northwest portion of the Central Sand Hills Ecological Landscape, widespread and prominent landforms include glacial moraines partially buried in outwash sands. As a result, soils have somewhat higher nutrient content than those in other sandy regions not influenced by morainal deposits. In some areas the water table is high. In the southeastern Central Sand Hills, moraines and drumlins are dominant landforms, and these were mostly not covered by outwash materials.
- Complexes of uplands, wetlands, and lakes occur in heterogeneous mosaics. Vegetation includes large areas of dry fire-driven oak forest, oak woodland, oak savanna, sand prairie, mixed pine-oak forest, tamarack swamp, shrub swamp, wet and wet-mesic prairies, sedge meadow, fen, and marsh.
- There are good opportunities to manage for dry forests. Most of these forests are oak-dominated, but there are some mixed stands



Figure 6.5. Ecological landscapes of Wisconsin.

- of pine and oak, which also merit conservation attention and management as natural communities.
- Landscape heterogeneity and the lack of large blocks of public land make it essential to work with private partners to effectively accomplish certain conservation goals in the Central Sand Hills Ecological Landscape.
- Several rare and highly localized small patch wetland communities are significant here, including Coastal Plain Marsh and Calcareous Fen. Both types support rare plants and invertebrates.
- Many seepages, springs, and coldwater streams originate in the prominent end moraines. Wetland communities associated with these seeps and springs include fen, sedge meadow, alder thicket, and tamarack swamp. Some of these are strongly calcareous.
- Several large, intact, species-rich wetland complexes of sedge meadow, wet prairie, fen, and tamarack swamp occur here. Protection of hydrological function, water quality, and water quantity are essential management considerations from a conservation perspective.
- Warmwater rivers such as the lower Baraboo, Montello, and Fox and a segment of the Wisconsin River are associated with significant floodplain communities, including some extensive marshes and bottomland hardwood stands. Remnant prairies and oak savannas still exist at a few locations.
- Several large shallow, marshy lakes (such as Buffalo and Puckaway) occur here, as does Green Lake, the deepest inland lake in Wisconsin.

## Central Sand Plains

- Extensive dry forests of pine, oak, and aspen occur here. There are opportunities to manage these forests at large scales, maintaining or creating forest interior conditions, and to maintain large forest patches, which have declined in most parts of southern Wisconsin.
- Among the rare species breeding in conifer-dominated dry forests are the U.S. Endangered Kirtland's Warbler, Connecticut Warbler (*Oporornis agilis*), and Red Crossbill (*Loxia curvirostra*).
- Old-growth management is appropriate and needed for some forest communities, especially (though not exclusively) in forests of pine and/or oak on dry-mesic sites, in wet-mesic white pine-red maple forests, in mesic maple-basswood forests (which are rare here), and in lowland hardwood forests within the major river corridors. These forest communities have high potential to grow large trees, develop complex stand structure, and support populations of rare animals requiring older forests.
- Restoration and management opportunities for globally rare Pine Barrens and Oak Barrens communities are still good at some locations. Ongoing projects need to be expanded where possible.
- On public lands in the southwestern part of this ecological landscape there are opportunities to improve the integration of dry forest management with pine and oak barrens, develop large habitat patches where needed to increase area, restore connectivity, reduce high-contrast edge, and maintain scattered openings within areas that are otherwise mostly forested and that will support rare light-demanding species. Several of the county forests have engaged in actions to make this a reality. Such efforts need to be expanded, and the State of Wisconsin could play a much more active role in addressing issues and conflicts associated with managing for both dry forests and barrens communities.
- Acid peatlands (bog, poor fen, wet meadow, shrub swamp, and conifer swamp) are abundant in parts of the Central Sand Plains and support many rare or otherwise sensitive species. Protection or restoration of hydrology is critical.
- Several of the larger rivers and streams here, especially the Black, Yellow, Lemonweir, East Fork of the Black, and free-flowing segments of the Wisconsin, are associated with extensive corridors of forested floodplain. These are especially important for migratory and resident birds, including rare species.
- Among the rare communities that are well represented in the Central Sand Plains Ecological Landscape compared with other parts of the state and that also provide habitat for rare species are Pine Barrens, Oak Barrens, White Pine-Red Maple Swamp, and Coastal Plain Marsh.
- Unusual exposures of Paleozoic sandstones are prominent here, especially where they protrude from the level sand plain. These features provide habitat for bedrock specialists and lend a *physiognomic aspect* to this region found nowhere else in Wisconsin or in any of the adjoining states.
- Public lands are more extensive here than in any other ecological landscape in southern Wisconsin.
- Surrogate grasslands are extensive east of the Wisconsin River, where they provide critical habitat for many rare and declining grassland birds and other species.

## Forest Transition

- Historically the Forest Transition Ecological Landscape was almost entirely forested. Extensive, unbroken forests are now confined to the eastern edge of the ecological landscape where large-scale forest management opportunities are greatest within the Chequamegon-Nicolet National Forest and the Menominee Reservation.
- Embedded within the extensive conifer-hardwood forests of the easternmost part of the Forest Transition Ecological Landscape are scattered lakes, wetlands (including some very large northern white-cedar swamps), spring ponds, and coldwater streams.
- The extensive forest cover in the eastern part of the ecological landscape is one of the primary factors that contributes to the high water quality found in many of the lakes and streams.
- Calcareous till and/or groundwater in the eastern part of the landscape provide the conditions needed by rare plants associated with alkaline waters and wetlands. Lakes in which marl deposition occurs are found in this area, and marl flats adjoin several lakes.
- The western range limits of several dominant tree species, including eastern hemlock and American beech, occur within this ecological landscape. The Forest Transition Ecological Landscape has a latitudinal span of almost 200 miles from east to west. Plant community composition is quite variable, partly a reflection of this breadth, the diverse composition of the glacial deposits within the landscape, and climatic factors.
- The corridors of large rivers such as the Wisconsin, St. Croix, Chippewa, and Wolf provide important north-south linkages across and between landscapes. Maintaining or restoring ecological connectivity along these river corridors is a high priority management opportunity.
- The St. Croix, Chippewa, and Wolf rivers support important aquatic biodiversity as do some smaller streams such as the Eau Claire, Oconto, Plover, Prairie, and Rib rivers.
- The western portion of the ecological landscape includes local concentrations of kettle lakes, and extensive oak

forests or mixed forests of oak and white pine. However, public ownership is limited and there are few large contiguous private ownerships.

- The lower St. Croix River forms the western boundary of the Forest Transition Ecological Landscape, a unique area with white pine and oak forests, and frequent outcroppings of igneous bedrock (mostly basalt). Cliffs and glades (or “balds”) supporting unusual assemblages of sparse savanna-like vegetation are locally common. The St. Croix River is bordered by some of western Wisconsin’s northernmost stands of Floodplain Forest, which support rare animals.
- The St. Croix River itself is exceptionally important for the high aquatic biodiversity it supports, including rare fish and globally rare mussels. Numerous springs and seeps occur at the bases of the forested bluffs flanking the St. Croix River.



The Chequamegon-Nicolet National Forest’s Cathedral Pines State Natural Area is an example of old-growth pine-hemlock forest, a rare type that was once much more common in the state. The Forest Transition Ecological Landscape, now largely dominated by agriculture, has retained extensive forested areas in its easternmost portion where this site is located. Photo by Thomas Meyer, Wisconsin DNR.

- The central portions of the Forest Transition Ecological Landscape are now used primarily for agricultural purposes. Habitat fragmentation is severe, but some of the remnant forests in this area are floristically rich and merit additional conservation attention, including basic field surveys.

## North Central Forest

- The North Central Forest is one of Wisconsin’s largest ecological landscapes. It is the only large ecological landscape with such a high percentage of forest cover. The North Central Forest Ecological Landscape offers the best opportunities in the state for large-scale forest management, including the maintenance of connectivity across multiple ownerships and jurisdictions.
- Opportunities to restore missing or diminished native forest *cover types*, especially conifers such as eastern hemlock, eastern white pine, northern white-cedar, and tamarack (*Larix laricina*); successional and developmental stages (old-growth stands are virtually absent at this time); and large habitat patches are exceptional because of the capability of the land, the large public land base, and the presence of remnant stands to serve as templates for the restoration of these features.
- Some of the best large-scale interior forest management opportunities occur where bedrock, the abundance of wetlands, or a high water table have limited other land uses, including infrastructure development. Important parts of the North Central Forest Ecological Landscape from this perspective include the Penokee Range (Penokee-Gogebic Range), the Blue Hills, and an area centered on the Headwaters Wilderness Area of the eastern Chequamegon-Nicolet National Forest. Rugged terminal moraines such as the Perkinstown Moraine and portions of the Winegar Moraine also offer legitimate large-scale forest management opportunities.
- Numerous forest interior specialists are present as are wide-ranging mammals requiring large areas of suitable habitat. For at least some, perhaps many, of these species, the North Central Forest and several of the adjoining ecological landscapes might be considered as part of a continentally important *population source* area.
- Important forested wetland communities such as northern white-cedar swamps and ash-dominated hardwood swamps are well represented across this ecological landscape.
- Acid conifer swamps dominated by black spruce (*Picea mariana*) or tamarack are common, and there are large and essentially undisturbed examples of these forested peatland communities here.
- Shrub and herb-dominated wetland communities are widespread in this ecological landscape. Especially important wetland types from these groups because of their size,



Large, undisturbed peatland complex in the North Central Forest. Vegetation grades from open muskeg to a heavily forested conifer swamp. These peatlands are connected to a completely undeveloped 94-acre seepage lake with various smaller wetlands. An extensive matrix of working hardwood forest surrounds the lake and wetlands. Bass Lake Peatlands State Natural Area, Price and Sawyer counties. Photo by Eric Epstein, Wisconsin DNR.

context, and condition include Alder Thicket, Poor Fen, Muskeg, and Emergent Marsh–Wild Rice.

- The headwaters regions of some of Wisconsin's largest rivers are here, where the high percentage of forest cover and the relatively low amount of cleared and developed land have contributed to the maintenance of high water quality.
- Extensive areas of glacial till with impeded drainage support concentrations of ephemeral ponds, small-scale aquatic features of critical importance to specialized invertebrates and herptiles such as fairy shrimp and salamanders.
- Exposures of bedrock are limited to a few areas within the North Central Forest Ecological Landscape but include glades and canyons in the Penoque-Gogebic Range, waterfalls along the northwestern edge of the ecological landscape, and quartzite gorges and talus slopes in the Blue Hills. Some of these sites support rare habitat specialists that occur in no other environments.

## Northeast Sands

- Xeric forests of pine, oak, and aspen are widespread and common. Other important natural communities include dry-mesic forests of eastern white pine and red pine, and localized areas of mesic northern hardwoods and hemlock-hardwoods. Some of the latter forests include a significant component of American beech, a species that reaches its western range extremities here.
- Management potential for Pine Barrens and Bracken Grassland communities is high at some locations. Some of Wisconsin's largest stands of Bracken Grasslands are in

the northeastern part of this ecological landscape. Important sites at which management has been initiated to maintain these semi-open communities include Spread Eagle Barrens State Natural Area (Florence County) and Dunbar Barrens State Wildlife Area (Marinette County).

- The Athelstane area (Marinette County) still contains good quality though scattered and diminishing barrens remnants, with higher representation of native prairie plants compared with the semi-open habitats farther to the north.
- Northern white-cedar swamps (Northern Wet-mesic Forests) are locally common and include some of the largest sites in the state. The huge Brazeau Swamp is unfortunately bisected by a state highway, which has altered hydrology and significantly damaged parts of this important forested wetland. Excessive deer browse is evident throughout the northern white-cedar and hemlock forests here.
- The eastern portion of the heavily forested Menominee Reservation is within the Northeast Sands. Some excellent lakes, streams, and spring ponds occur here as do some large northern white-cedar swamps.
- Significant aquatic features include many coldwater and coolwater streams and several medium-size warmwater rivers. Important stretches of the Pine, Popple, Peshtigo, Pike, and Menominee rivers occur in the Northeast Sands.
- Scattered lakes are present, some with associated bog or fen vegetation, others with sandy upland shores. Marl-bottomed lakes are important in this ecological landscape and need additional investigation. Undeveloped lakes are concentrated on the larger public lands, but there are several clusters of undeveloped lakes on private holdings.
- Granitic bedrock outcroppings are significant features along the Menominee and Peshtigo rivers and at scattered locations in the southern portion of the ecological landscape. Specialized biota are associated with the cliff, glade, and talus communities. Waterfalls occur along some streams here.
- Large working forests make up an extensive portion of the Northeast Sands Ecological Landscape (e.g., the Marinette County Forest alone is approximately 220,000 acres in size), but the forest cover throughout much of this ecological landscape is somewhat fragmented by the emphasis on *short rotation* early successional species, numerous pine plantations, and associated infrastructure.
- *Old forests* are poorly represented here and continue to decline. In a few areas there may be opportunities to develop older stands of hemlock-hardwoods (with American beech) and to work with dry-mesic white pine-red pine forests and wet-mesic northern white-cedar swamps as well. Better incentives are needed for the counties and private landowners to maintain or allow for the development of older forest in appropriate areas.

## Northern Highland

- The Northern Highland is an extensive glacial outwash plain with more limited areas of moraine and a few small drumlin fields. The pitted outwash landforms contain a globally significant concentration of glacial lakes, including lake types that are rare.
- The Northern Highland Ecological Landscape is uniquely situated in that it is bordered on three sides by national forests (the Chequamegon-Nicolet and the Ottawa) and other public lands. The Wisconsin River flows southward, and the river corridor provides a degree of connectivity with landscapes of central and southern Wisconsin.
- Major management opportunities in the Northern Highland Ecological Landscape are pinery restoration, lake and shoreline protection, and the conservation of large acid peatlands. Similar opportunities in the adjoining ecological landscapes are either nonexistent or occur at greatly reduced scales.
- Historically the matrix vegetation here was an extensive dry-mesic forest dominated by large eastern white and red pines. Though virtually all of the original pinery was cut and/or burned during the Cutover, the Northern Highland represents the best statewide opportunity (and one of the best region-wide opportunities as well) to restore extensive forests dominated by large white and red pines. A few older pine forest remnants have persisted, and in some areas, eastern white pine recovery under white birch (*Betula papyrifera*) and quaking aspen (*Populus tremuloides*) has been strong.
- At a few locations there are mesic hardwood and hemlock-hardwood forests large enough to support area-sensitive forest interior species. Some of these stands are moderately large (over 1,000 acres), and several of them are now developing old-growth attributes.
- Acid peatlands are common here, and some of them are extensive. Major peatland communities include Muskeg, Open Bog, Poor Fen, Tamarack Swamp, and Black Spruce Swamp. Highly specialized plants and animals adapted to the harsh peatland environments are well represented in the Northern Highland Ecological Landscape.
- Lakes and streams supporting extensive beds of wild rice occur here. Wild rice marshes are relatively common in the Northern Highland where they are important ecological and cultural resources.
- Rare lake types include the extremely *oligotrophic*, deep, sand-bottomed seepage lakes that support an unusual flora of aquatic macrophytes that are of limited distribution in Wisconsin. Rare invertebrates also inhabit some of these lakes. Some drainage lakes and spring ponds may also be considered relatively rare or geographically restricted aquatic features.

- Small to medium-sized streams that connect lakes are very well represented here. Shoreline development and loss or disruption of important shoreline habitats is an increasing problem for stream and lake biota.
- Along the northern edge of this ecological landscape below the Winegar Moraine there are significant opportunities to protect extensive swamps composed of northern white-cedar and black ash (*Fraxinus nigra*). Some old-growth hemlock-hardwood remnants are associated with these areas, which have a boreal flavor owing to the presence of white spruce (*Picea glauca*) and balsam fir (*Abies balsamea*) as canopy and understory trees.

## Northern Lake Michigan Coastal

- The least disturbed part of Lake Michigan and a diverse assortment of rare and geographically restricted shoreline features are found here.
- The Door Peninsula and Grand Traverse Islands archipelago provide the environmental setting for important shoreline features such as forested ridge-and-swale complexes, beach and dune systems, extensive exposures of dolomite bedrock and cobbles, a unique boreal forest community variant on shallow soils over dolomite bedrock or cobbles, coastal embayments with large lakes, and extensive wetlands (some of them estuarine) of sedge meadow, marsh, fen, and conifer swamp.
- The Niagara Escarpment is a unique geological feature that has important associated ecological attributes including cliffs, talus slopes, unusual forests that contain some of Wisconsin's oldest trees (see the Northern Lake Michigan Coastal Ecological Landscape chapter), and habitats for many rare species, most notably for globally rare terrestrial snails.
- Outstanding examples of freshwater estuaries, such as the Mink River Estuary, occur on the Door Peninsula.
- The Door Peninsula and some of the Grand Traverse Islands feature strongly calcareous bedrock and soils that provide habitat for specialized plants, some of them quite rare.
- The eastern portion of this ecological landscape supports one of the greatest concentrations of rare plants and animals in Wisconsin. Only areas in Michigan's Upper Peninsula and on northern Lake Huron are comparable. Among the rarities are globally rare land snails, insects, and plants, some of them endemic to Great Lakes shoreline environments.
- Green Bay and the waters of Lake Michigan provide important habitat for numerous migratory, resident, and wintering birds.
- The west shore of Green Bay supports an extensive band of coastal wetlands (marsh, sedge meadow, shrub swamp,

bottomland hardwoods) of varying width that provides critical habitat for birds, fish, and native plants. In recent years, the highly invasive common reed (*Phragmites australis*) has exploded and taken over many of these wetlands, reducing diversity and creating daunting challenges for managers and conservationists.

- West and north of Marinette the landscape is complex and dominated by numerous drumlins interspersed with wetlands. The groundwater is somewhat calcareous, and swamps of northern white-cedar, ashes, and tamarack are common. Small lakes bordered by open wetlands and shrub swamps are also present in this area, which needs additional study.
- The Menominee River forms the northern boundary of this ecological landscape and offers important management opportunities for aquatic organisms, several wetland communities (including some, such as Floodplain Forest, at their northern range limits), and rare plants.
- A short, free-flowing stretch of the ecologically significant lower Wolf River flows through the westernmost part of the Northern Lake Michigan Coastal Ecological Landscape.
- Several important warmwater streams enter Green Bay from the west and are used seasonally by native warmwater fish and by introduced populations of salmonids that make spawning runs from Lake Michigan (the introduced species do not reproduce successfully in these streams).

## Northwest Lowlands

- The Northwest Lowlands is one of Wisconsin's least developed ecological landscapes. Human population and infrastructure densities are low. This ecological landscape is part of a large glacial till plain that occurs mostly in Minnesota.
- The uplands are extensively forested, mostly with young to medium-aged stands of northern hardwoods and aspen. Much of this land would be considered "working forest" as it is managed primarily for timber products.
- Large undisturbed peatland mosaics of conifer swamp, bog, fen, and sedge meadow are present and are among the largest and least disturbed in Wisconsin. Good examples are Black Lake, Belden Swamp, the Erickson Creek-Mud Lake Peatlands, and the Empire Swamp. These large peatlands occur within forested watersheds and provide high quality habitat for many sensitive plants and animals, including rare species.
- A lengthy portion of the St. Croix River runs along the southern boundary of the ecological landscape. The St. Croix River system is of extremely high ecological significance for the diverse aquatic biota it supports and for its association with excellent occurrences of many natural

communities. Numerous springs and seeps feed the St. Croix and some of its tributaries.

- Some of the second-growth northern hardwood and aspen forests include a significant component of boreal conifers such as balsam fir and white spruce; there may be some potential to diversify and manage some of these forests as boreal-transition forest.
- Pine, especially eastern white pine, was historically important in some areas but is now scarce. Restoration opportunities need to be identified.
- The topographic surface of much of the Northwest Lowlands consists of northeast-southwest trending bedrock ridges that lie beneath glacial till, creating a pattern of alternating uplands and wetlands, with parallel stream courses in the lowlands. Ecotones between uplands and wetlands are important, and in this ecological landscape, these are mostly intact.



*The St. Croix River is well known for having exceptional natural values and recreational uses, and it supports many rare species. Preserving the integrity of the numerous seeps and streams that feed the St. Croix is essential for maintaining its high quality, in addition to protecting the steep slopes, spring recharge areas, and the overall watershed. Brant Brook Pines State Natural Area. Photo by Drew Feldkirchner, Wisconsin DNR.*

- Many headwaters streams originate within and flow through undeveloped and almost entirely forested watersheds. Most of these streams are free-flowing, and relatively few of them have been impacted by agricultural or urban-industrial activities.
- Wide-ranging animals are found in this ecological landscape, including gray wolf, bobcat (*Lynx rufus*), and an occasional moose (*Alces alces*).
- This landscape is an important dispersal corridor for the gray wolf and other large mammals.

### Northwest Sands

- The Northwest Sands Ecological Landscape contains the best opportunity in the Upper Midwest to manage for and restore globally rare Pine Barrens and Oak Barrens communities—especially at large scales.
- While the management emphasis has been to restore or create barrens in which the trees (now mostly oaks) are reduced to shrub size (“grubs”), barrens structure is potentially far more diverse, and some of this variability could be represented somewhere in the Northwest Sands. For example, transition areas between open barrens and dense forests could be managed more as savannas with scattered larger trees or groves of trees. When communities as dynamic as barrens are managed as static entities, their maintenance over time can be problematic.
- Xeric forests of pine and oak are extensive and should be maintained. Forests in which jack pine, scrub oak, and natural red pine are dominant have declined, and they are now significantly underrepresented in some parts of Wisconsin. The Northwest Sands Ecological Landscape presents an excellent opportunity to address these declines.
- Jack pine and scrub oak would benefit from more recognition that they are important “early successional” cover types and that they have declined in most parts of Wisconsin.
- Compatibility when managing for barrens and dry forests could be improved. Some barrens could be functionally, if temporarily, enlarged when planning timber sales in dry forests, and barrens patches could be periodically connected between rotations of trees on lands where timber production is the primary goal.
- The retention or creation of small patches of barrens habitat within areas of intensively managed forest will help to conserve native flora and fauna adapted to and dependent on semi-open conditions. More explicit guidelines are needed for managers who wish to identify and incorporate such patches (refugia) into their management plans.
- Many rare species are highly dependent on the maintenance and restoration of barrens communities, including

some that are area-sensitive, have poor dispersal abilities, and are dependent on habitats of specific structure and/or composition.

- Several of Wisconsin’s largest and least disturbed sedge meadows occur in the southern part of this ecological landscape, and they support many rare animals. Those adjoining open barrens are especially effective in supporting area-sensitive open country species.
- Large firebreaks in the Northwest Sands Ecological Landscape have socioeconomic and ecological values. In addition to conferring a degree of protection to property, some of these serve as refugia for rare or conservative species and may also function as dispersal corridors for animals and some plants.
- Two of northwestern Wisconsin’s most prominent and important rivers, the St. Croix and the Brule, originate as springs in the same swamp in southern Douglas County. Protection of this headwaters area, which is crossed by a county highway, is of paramount importance, and every effort should be made to maintain the hydrology of this area within its range of natural variability.
- Lakes are locally numerous in several areas of pitted glacial outwash within the Northwest Sands. Development pressures are high, and relatively few of these waterbodies have been protected. Additional lake and shoreline protection is a conservation opportunity, priority, and need here.

### Southeast Glacial Plains

- Much of the Southeast Glacial Plains Ecological Landscape is a level to gently rolling till plain with highly productive soils. This is one of Wisconsin’s largest, most severely fragmented, highly disturbed, and intensively developed ecological landscapes. As a result, the Southeast Glacial Plains contains an especially high concentration of rare natural communities, aquatic features, plants, and animals.
- Glacial landforms are diverse and prominent and include drumlins, eskers, and kames as well as more extensive areas of ground moraine, end moraine, and outwash.
- An extensive interlobate moraine (the “Kettle Moraine”) crosses much of the eastern part of the Southeast Glacial Plains. The rough topography has limited land use options, and until recently this region was especially notable because it was less developed than most other parts of this ecological landscape.
- The South Kettle Moraine contains multiple examples of globally rare natural communities such as tallgrass prairies (Wet Prairie, Wet-mesic Prairie, Mesic Prairie, and Dry-mesic Prairie), oak savannas (especially the globally imperiled Oak Openings), and alkaline fens (Calcareous Fen). Due to long periods of fire suppression, many of the

savanna and woodland communities have become dense “forests,” which are of now high importance regionally to forest interior songbirds and other area-sensitive forest species. Important conservation lands within the southern Kettle Moraine include the Southern and Lapham Peak units of the Kettle Moraine State Forest, a cooperative partnership led by the Wisconsin Chapter of The Nature Conservancy and the Wisconsin DNR to protect and restore the Mukwonago River watershed, and several key projects led by local land trusts and private citizens.

- The trick for planners and managers of the lands and waters in and around the southern Kettle Moraine will be to enlarge, restore, and reconnect the fragmented grassland (including prairies, meadows, fens, marshes, and old fields) and savanna remnants without unduly compromising the overall amount of interior forest in the ecological landscape. This will be one of several major ecological planning issues for the Kettle Moraine State Forest during the development of a new master plan for that property.
- The northern Kettle Moraine (unlike the southern Kettle Moraine) was heavily forested historically and now provides the largest contiguous area of upland forest in the southeastern quadrant of the state. The northern Kettle Moraine also contains embedded wetlands dominated by “northern” plant species, including conifers such as tamarack and northern white-cedar. Black spruce reaches its southern range limits here but is very rare.
- The northern and southern parts of the Kettle Moraine may encompass the only blocks of upland forest large enough to provide breeding sites in the Southeast Glacial Plains that will support viable populations of many of the forest interior birds that nest there.
- The southernmost exposures of the Niagara Escarpment, a Silurian dolomite bedrock feature, are in the eastern

part of this ecological landscape. Associated habitats include dry cliffs and talus slopes, mesic maple-beech forests, and an abandoned mine that hosts a regionally significant bat hibernaculum. Globally rare terrestrial snails inhabit stretches of the escarpment.

- Large, productive marshes are characteristic of this ecological landscape. These include Horicon, Eldorado, and Theresa marshes, plus the lower Wolf River, Rush Lake, and Grassy Lake. Dam construction has been common on rivers in the Southeast Glacial Plains (to provide power or flood control and to facilitate the use of motorized watercraft) and has resulted in the conversion of vast areas of marsh and meadow to open water by raising water levels.
- The state’s largest Southern Sedge Meadow is the most extensive wetland community within the White River-Puchyan River wetland complex in Green Lake County, which also includes significant stands of marsh, wet prairie, fen, and tamarack swamp.
- The floodplain of the lower Wolf River flows through the most extensive lowland hardwood forests in eastern Wisconsin and, with its tributary, the Rat River, crosses a huge marsh complex just before entering the Winnebago Pool lakes at Lake Poygan.
- Large, shallow lakes such as Koshkonong, Sinissippi, and the Winnebago Pool are of critical importance to birds, herptiles, fish, and other aquatic species. The Winnebago Pool lakes and the Wolf River system are especially notable for the globally significant population of lake sturgeon they support.
- Many lakes and many streams in this ecological landscape have water quality problems. In some areas, excessive groundwater withdrawals are negatively impacting wetlands and stream flows.
- The Mukwonago River watershed has been justly singled out for protection because of the exceptionally high diversity of native aquatic organisms it supports and the equally significant diversity of associated natural communities.
- Other important rivers and streams here (most of these are warmwater types) include the upper Milwaukee, Oconomowoc, Genesee, Bark, Sugar, and White rivers and Turtle Creek.
- Preserving or restoring wetlands and other riparian vegetation along rivers and streams is a high priority to improve water quality, maintain water quantity, and provide habitats that have been greatly diminished and fragmented over the past 150 years.
- Conifer swamps dominated by tamarack and, much more rarely, northern white-cedar are uncommon in southern Wisconsin. Composition and structure of these conifer swamps differ from occurrences found farther north. Many of the large tamarack swamps in southeastern



*Kettle Moraine Oak Opening is a state natural area that is being intensively managed with prescribed fire and woody species removal to restore degraded portions and link high quality areas. Photo by Thomas Meyer, Wisconsin DNR.*

Wisconsin were drained, cleared, and converted to muck farms in the early 20th century. Few of the remaining tamarack stands are in good condition, and there is an urgent need to develop effective restoration methods.

- Cedarburg Bog, a large wetland complex in the Southeast Glacial Plains, is influenced by alkaline groundwater and includes stands of northern white-cedar, black ash, and tamarack as well as semi-open patches of rich fen, sedge meadow, and marsh. This site is also notable as it is one of the southernmost patterned peatlands known from the Upper Midwest. This wetland is a rich repository of rare species, and many plants and animals of generally more northern distribution occur here.

### Southern Lake Michigan Coastal

- This very small ecological landscape on the southwestern Lake Michigan shore is the most densely populated and heavily developed part of Wisconsin.
- The Lake Michigan shoreline provides important habitat for huge numbers of migratory birds, including waterfowl, gulls, terns, raptors, and passerines. Large rafts of diving ducks winter on the offshore waters.
- The southeastern corner of Wisconsin is occupied by one of the Upper Midwest's outstanding prairie complexes. The muted ridge-and-swale topography contains a vegetation mosaic of Wet-mesic Prairie, Mesic Prairie, Calcareous Fen, Southern Sedge Meadow, and Oak Opening. The core of this site is Chiwaukee Prairie State Natural Area, which adjoins other natural features of high value immediately to the south within Illinois Beach State Park.
- Extensive surrogate grasslands with embedded marshes and small tallgrass prairie remnants occur at Richard Bong State Recreation Area in Kenosha County, an important breeding site for declining grassland birds. Additional marshes and other types of open wetlands also occur in southern Kenosha and Racine counties.
- Warmwater streams and associated riparian vegetation with relatively high conservation potential include the Root, Des Plaines, Pike, Kinnickinnic, Menomonee, and lower Milwaukee rivers. In some areas, everything else has been developed.

### Southwest Savanna

- Wisconsin's most open (least forested) ecological landscape is part of the Driftless Area. The combination of extensive open lands and limited forest cover makes this arguably the best area in the state in which to restore and manage effectively for grassland ecosystems at large scales.
- Prairie remnants, though small, are widespread and include sites of good quality and high diversity embedded within extensive surrogate grasslands. "Prairie pastures"

are grasslands altered by long periods of grazing but which have never been plowed. They differ from surrogate grasslands in that they retain more native plants and some prairie invertebrates and prairie soil microorganisms.

- Restoration opportunities for oak savanna are good in some areas, especially in pastured but unplowed stands that have retained the characteristic structural elements of savannas and in which native plants and animals have persisted to some degree.
- The entire continuum of southern Wisconsin's fire-dependent natural communities from treeless prairie, to oak savanna, to oak woodland, to oak forest is present here. Representing all of these types in conservation projects at scales that will support area-sensitive species is highly desirable as that offers the best chances of long-term success in responding to changing environmental conditions and of maintaining all associated plants, animals, and natural processes.
- Spring-fed coldwater streams are locally common and unique because they are, and historically were, surrounded by grasslands rather than forests.
- Some warmwater rivers and streams, such as the Pecatonica River, are associated with regionally rare community remnants such as lowland hardwood forest, sedge meadow, and marsh and provide connections with important conservation sites in adjoining parts of Illinois.
- Bedrock-controlled hills, including Platte Mound, Belmont Mound, Sinsinawa Mound, and the Blue Mounds, are prominent geological features that support dry-mesic to mesic hardwood forests and assemblages of plants and animals that are otherwise absent or extremely scarce in this ecological landscape.
- Conifer "relicts" occur at a few sites in the Southwest Savanna, usually on steep, cool, north or east-facing slopes where a stream has undercut bedrock. Eastern hemlock reaches its extreme southwestern range limits on these sites. Eastern white pine has a somewhat wider distribution, but is still limited to steep, rocky sites.
- In common with all other "border" landscapes, opportunities to manage across state lines should be identified and assessed. There may be potential to pool resources and address limitations associated with single administrative jurisdictions.
- Public lands are very limited here, making partnerships between state and local governments, nongovernmental organizations (NGOs), and individual landowners essential if effective conservation actions are to be achieved. Project coordination is challenging but essential to success.
- The recently established Southwest Wisconsin Grassland and Stream Conservation Area serves as a model for successful partnering to achieve mutual conservation goals.

## Superior Coastal Plain

- Lake Superior is the largest freshwater lake in the world by area. It is of immense ecological and socioeconomic importance, is the setting for a unique array of natural communities, and provides habitat for large numbers of migratory and resident birds and native fish that have disappeared or seriously declined elsewhere in the Great Lakes.
- The concentration of freshwater estuaries along the southwestern shore of Lake Superior is of global significance. Important natural communities in these coastal wetlands include fen, sedge meadow, marsh, wild rice marsh, and tamarack swamp. These in turn support numerous native plants and animals, including many that are rare.
- Sandspits are characteristic features of Wisconsin's Lake Superior coast, including the Apostle Islands. Associated natural communities include Great Lakes Beach, Great Lakes Dune, Interdunal Wetland, Great Lakes Barrens, and coastal pine and oak forests. All of these communities are rare, and each supports its complement of characteristic and rare species. In addition to their considerable intrinsic values, the sandspits protect river mouths, lagoons, and wetlands from wind, wave, and ice damage.
- The Apostle Islands archipelago contains exceptional examples of Great Lakes sandscapes, coastal cliffs, old-growth forests, and perched wetlands. The islands represent a regionally significant repository of rare biota and intact and unusual natural communities.
- Boreal Forest is the most extensive community type on the nearly level clay plain bordering the rugged Bayfield Peninsula, though at the present time most of these forests are heavily dominated by quaking aspen. Restoring diminished forest attributes such as conifers, large living and dead trees, large coarse woody debris, and large patches to this distinctive and geographically restricted community is a high priority, especially on public lands such as the Brule River State Forest and the City of Superior's Municipal Forest.
- The best opportunities to manage for Boreal Forest occur on the clay plain west of the Bayfield Peninsula, and to a lesser extent, around Chequamegon Bay. In many parts of the clay plain, the forest is now fragmented by scattered farms or other openings, so reforestation is a desirable restoration action on appropriate sites.
- Specific restoration items include increasing the long-term representation of boreal conifers and *supercanopy* eastern white pine, especially on public lands or in NGO projects where Boreal Forest protection and restoration has been identified as a priority management goal.
- Precambrian sandstones are exposed as cliffs and ledges on the north end of the Bayfield Peninsula and in the Apostle Islands archipelago. Highly specialized rare plants inhabit some of these bedrock features.
- Waterfalls occur on the southern margins of the Superior Coastal Plain where streams from the Northwest Lowlands and North Central Forest ecological landscapes cross bedrock ridges.
- The poorly drained red clay soils in the westernmost part of the Superior Coastal Plain support a diverse and unusual assemblage of rare plants, some of them occurring nowhere else in Wisconsin.
- Important river corridors include the St. Louis, Bad, Nemadji, Brule, Black, Amnicon, and Sand. Wisconsin's northernmost stands of Floodplain Forest are associated with the largest of these rivers, and older alluvial terraces just above the floodplain sometimes support floristically rich mesic maple-basswood forests. Slopes above the river terraces are, or were, forested with conifer-dominated stands of Boreal Forest. All of these river corridors provide a degree of ecological connectivity between sites within and across landscapes.
- The huge Bibon Swamp (roughly 10,000 acres) is connected to Lake Superior via the White River and Bad River corridors and to the North Central Forest Ecological Landscape and the Penokee Range via the White River. Prior to Euro-American settlement this swamp was mostly forested, dominated by northern white-cedar in some areas and various combinations of black spruce and tamarack elsewhere. At this time, the eastern two-thirds are dominated by tall shrubs such as willows and alder, with more limited areas of swamp hardwoods and conifers.
- Numerous coldwater streams come out of the deep sand deposits in the northernmost part of the Northwest Sands Ecological Landscape immediately south of the Superior Coastal Plain. Streams originating in the sands of the Bayfield Peninsula run through mostly forested



*Stockton Island Tombole contains an exceptionally diverse and complex association of rare or otherwise noteworthy natural communities on the southeast end of 10,000-acre Stockton Island. This site is a designated state natural area within the Apostle Islands National Lakeshore. Photo by Eric Epstein, Wisconsin DNR.*

watersheds, across areas of glacial till, and through lenses of sand or sandstone bedrock and tend to be much clearer than the often sediment-laden streams that originate in and flow primarily through the red clay soils.

- Surrogate grasslands are common in some of the more level areas where they are the result of converting forests to crop or pasture land. Though most of these sites are privately owned, a few of the larger blocks of open land support area-sensitive grassland birds, including Sharp-tailed Grouse, Upland Sandpiper, and Northern Harrier (*Circus cyaneus*). In general, managing and restoring forests should be a higher priority here than managing for grasslands, but there may be a few sites that would merit consideration as exceptions. These have yet to be identified across the ecological landscape.
- In areas where the red clay soils are interlayered with sand, steep slopes are easily downcut and eroded. This instability makes them prone to slumping. Many streams in the Superior Coastal Plain Ecological Landscape were badly damaged during the Cutover and many decades later have yet to recover.
- Excessive browse by white-tailed deer (*Odocoileus virginianus*) is a serious problem throughout much of the Superior Coastal Plain. Areas east and west of the Bayfield Peninsula are significantly fragmented, and there has been an emphasis on maintaining extensive areas of early successional forest, with quaking aspen (a preferred deer food) as the primary cover type.
- Other features of high significance associated with the major rivers include the largest stands of bottomland hardwoods in the Upper Midwest; extensive upland hardwood forests; bluff prairies; oak savanna and woodland remnants; broad sand terraces with remnant Oak Barrens and Sand Prairie vegetation; sand bars and mud flats; and nonforested wetlands such as marsh, sedge meadow, wet prairie, and shrub swamp.
- Dry bluff prairies are more abundant here than anywhere else in the Upper Midwest. Many of these prairies are directly associated with management opportunities for oak savanna, woodland, and forest. Dry sand prairies are also well represented at a few sites away from the large rivers, such as Fort McCoy Military Reservation, which has exceptional Oak Barrens and Sand Prairie complexes that in turn support many rare plants and animals.
- Geologic features include cliffs, glades, talus slopes, and extremely rare natural communities such as Algific Talus Slopes. Depositional features such as sand bars and mudflats can be included here as well. These habitats support migratory birds and many specialists, including rare species. Caves and abandoned mines contain important bat and herptile hibernacula.
- Spring-fed coldwater and coolwater streams occur in many parts of this ecological landscape and offer numerous opportunities to protect a wide variety of *nongame* and game species along with their aquatic and riparian habitats.
- The Mississippi Flyway is used by hundreds of thousands, perhaps millions, of migratory birds each spring and fall. For example, a large proportion of the Canvasback and Tundra Swan populations use the Mississippi River as staging areas during migration.
- Despite the size of the Western Coulees and Ridges Ecological Landscape and the many distinctive features occurring there, there is relatively little public land. Most of the existing public land is associated with the large rivers. There is need for additional protection projects along the river corridors and bluffs and, especially, within this ecological landscape's interior. Partnerships with NGOs, private citizens, and local governments will be extremely important here.

## Western Coulees and Ridges

- The Western Coulees and Ridges is Wisconsin's largest ecological landscape and occupies much of the Driftless Area. The absence of past glaciation has resulted in distinctive landforms, drainage patterns, bedrock features, and species assemblages, making it a unique upper midwestern landscape.
- The entire continuum of fire-dependent natural communities is present here and includes prairies, savannas, woodlands, and oak forests.
- Hardwood forests on dry-mesic, mesic, and wet sites are more extensive here than in other parts of southern Wisconsin. Collectively they offer the best opportunities to manage at large scales, to maintain forest interior conditions, and to include major environmental gradients (e.g., slope, aspect, soil moisture, soil texture, soil type), which may be more likely to accommodate future environmental changes, thereby enhancing long-term community and ecosystem viability.
- The major rivers, including the main stems and riverine lakes of the Wisconsin, Chippewa, Black, and Mississippi river systems, offer exceptional opportunities to conserve globally important aquatic diversity.

## Western Prairie

- The western part of this ecological landscape is a rolling till plain that still offers good opportunities to manage for open conditions at relatively large scales. The eastern portion of the Western Prairie Ecological Landscape is dissected by streams and is more heavily forested. Agriculture had been the overwhelmingly dominant land use in the fertile uplands here since Euro-American settlement, but in recent years residential development has increased explosively, especially in areas near the St. Croix River and

other waterbodies. Much of this increase is related to the growth of the Twin Cities.

- Important natural communities and habitats include tall-grass prairie remnants, large areas of surrogate grassland, prairie pothole lakes and associated wetlands, and potentially restorable remnant oak openings. The federal *waterfowl production areas* and state wildlife areas offer good grassland management cores.
- The St. Croix River corridor harbors good quality wetlands (Floodplain Forests, Emergent Marsh, Wet Prairie) and wooded bluffs, which contain dry prairie, sand prairie, oak savanna, and oak forest remnants. The river itself is significant for the high aquatic diversity it supports.
- The dry dolomite cliffs along the St. Croix River support rare species, mostly bedrock specialists or prairie species.
- Small patches of prairie are scattered throughout the western part of the Western Prairie Ecological Landscape. Most of these are isolated, persisting in rights-of-way, cemeteries, on steep bluffs, and on other undeveloped sites. The protection and management of some of these would make excellent projects for local conservation groups.
- Some of the remnant prairies here support plant species that are more typical of the Great Plains and have reached their extreme eastern range limits in western Wisconsin.
- Some rivers and streams support significant recreational fisheries. The corridors associated with these waterbodies offer opportunities to protect and manage forests, cliffs, and small wetlands.
- Residential development pressures are very high and will pose major economic and ecological challenges to managers and planners of conservation projects at all scales.
- Recreational uses of the St. Croix River can be very high and are not always compatible with protecting the sensitive natural features of the river and its surroundings.

## Integrated Ecological and Socioeconomic Opportunities

Use of natural resources for human needs within the constraints of sustainable ecosystems is part of ecosystem management. Integrating ecological management with socioeconomic programs or activities can result in efficiencies in the use of land, tax revenues, and private capital. This type of integration can also help generate broader public support for sustainable ecosystem management. However, any human modification or use of natural communities has trade-offs that benefit some species and harm others. Even activities such as ecotourism can have an impact on the ecology of an area. Although ecotourism most often affects the

ecology of an area much less than resource extraction, it can still lead to overuse of an area, disturbance to sensitive wildlife and plants, water quality degradation, and introduction of invasive exotics. Trade-offs caused by any management action need to be carefully considered when planning management to ensure that some species or natural communities are not being irreparably harmed. There needs to be a balance between resource use for human needs and sustaining functional ecosystems to provide natural resources for future generations and the *ecosystem services* that society too often ignores or takes for granted.

Lands managed for resource extraction can provide habitat for some species of wildlife and can also provide recreation and products for people. However, to sustain all species and natural communities in the state, some lands need to be managed to provide habitat for sensitive and declining species and natural communities where resource extraction is not the primary goal. Some lands and waters need to be managed for rare species or they will be lost. Lands with renewable resources managed for resource extraction should be managed as sustainable ecosystems. Nonrenewable resources (e.g., mines, gravel pits, etc.) should be managed in an environmentally appropriate way that protects ground and surface waters and avoids damaging or fragmenting the surrounding vegetation to the highest degree possible.

An example of land managed with resource extraction as its primary goal is when forestland is managed for sustainable production of timber while providing habitat for some wildlife species and allowing public access for recreation. The forest vegetation and the animals it supports can coexist with the people who come to the area to recreate, thereby generating revenue from activities like bird watching, hunting, or snowmobiling. The forest must remain sustainable and attractive to people who may want to recreate there for this integration to persist.

Another example is that when wetlands are maintained or restored, they provide retention of storm water, decreasing flood damage downstream; reduce nutrient and sediment loads in the water thus improving water quality; provide habitat for many fish and wildlife species; and provide recreation for anglers, hunters, and bird watchers.

An example of land managed primarily for the benefit of rare or declining species and natural communities would be allowing some blocks of forest to reach older ages by forgoing timber harvesting there. However, harvesting stands on the perimeter of these areas can provide timber products and a forested *buffer* to maintain some characteristics of a larger block of forest. This approach still allows socioeconomic returns from the forest as a whole but provides habitat for rare and area-sensitive wildlife that can be found nowhere else.

Managing species so they don't become rare and require listing as endangered or threatened provides the societal benefit of reducing long-term management costs. Once listed as endangered or threatened, these species require a formal

recovery plan. Further, use restrictions may be imposed, limiting management options. The entire recovery process can be long and expensive, with many societal costs and uncertain outcomes. Using long-term planning to ensure that species populations don't decline to low levels can avoid these costs. Monitoring what we manage is an essential component to understanding the impacts of our land use policies and management actions. Responding adaptively to the results of well-designed monitoring efforts can reduce or eliminate the need for formal statutory listing and the procedures that follow, at least in some cases.

Maintaining healthy, sustainable ecosystems provides many benefits to people and the economy. These benefits are often called "ecosystem services." Recent research has begun to quantify the economic value of ecosystem services to people and the economy. Among the valuable ecosystem services provided are

- wetlands and native shoreline vegetation that maintain good water quality and potable groundwater and reduce flood damage;
- aquatic systems that support the food web in our waters and produce fish and a multitude of other organisms;
- storage and sequestration of carbon by forests, grasslands, and peatlands that can mediate climate change;
- the productive capacity of forests that provides forest products and supports wildlife;
- grasslands that maintain good soil health and retention, water quality, and potable groundwater and result in a reduction in flood damage;
- the productive capacity of grasslands, which enables the production of agricultural products and wildlife;
- aesthetic areas that maintain a higher quality of life; and
- species that may have undiscovered future economic or social benefits.

The following management actions could be taken to integrate ecosystem management with socioeconomic opportunities. Many ecosystem services are contained within the following examples.

### **Forest Certification**

**Forest certification** is a process for ensuring that areas are being managed sustainably. Forests are certified by independent organizations to ensure that the results of the landowners' management meet standards for ecological, social, and economic sustainability. Because many end users of wood products are requiring the use of certified wood, certification helps Wisconsin remain competitive in global markets.

Forest certification does not, itself, prescribe specific management practices. Instead, agencies or other landowners are expected to develop management plans and follow their own

management practices within the sideboards provided by the principles and criteria of the certifying body. Third-party certification requires periodic audits of forest management by an accredited certifying organization to make sure that forests are managed following the appropriate standards and principles.

In Wisconsin, virtually all state-managed lands, many county forestlands, and most non-industrial **Managed Forest Law** lands are certified using standards developed by the Sustainable Forestry Initiative (SFI), the Forest Stewardship Council (FSC), or both. The Chequamegon-Nicolet National Forest was one of five national forests evaluated against standards of the FSC and SFI in recent years (Sample et al. 2007), but certification has not been pursued there as of this writing.

### **Diversifying Forests**

Landowners and land managers will sometimes have the opportunity to increase the abundance or extent of diminished or missing forest communities, successional and developmental stages, structural features, and key species. Examples, in the appropriate locations and environmental settings, could include better representation of important trees such as white pine or yellow birch (*Betula alleghaniensis*), a component of old and very large trees, multi-layered canopies, coarse woody debris, and natural stands of conifers. In some landscapes, an early successional forest emphasis would be warranted, including stands of jack pine, scrub oak, and tamarack. In the appropriate settings, over time such managed forests would provide both socioeconomic and ecological benefits, including habitat for rare or otherwise sensitive plants and animals and forest products that would be difficult or impossible to obtain elsewhere. This approach to management could play a significant role in maintaining the entire mosaic of plant communities, age and size classes, habitats, and forest patch sizes that characterize a given landscape.

### **Natural Red Pine/Jack Pine/Red Oak Regeneration**

Developing ways to reliably regenerate natural stands of red pine, jack pine, northern red oak (*Quercus rubra*), or mixed stands of pine and oak will provide ecological benefits as well as reduce costs of timber management. Using natural regeneration allows native vegetation and the animals dependent on it to survive. Artificial planting and spraying or killing native vegetation to reduce competition is expensive and greatly reduces the ecological value of a previously natural forest site. Greatly disturbing the soil and using heavy equipment brought from other places may allow the introduction of invasive plants, further increasing management costs if they have to be controlled.

### **Urban Forestry**

Planting trees in urban areas increases aesthetic and property values to homes, provides shade that reduces energy costs of cooling homes in summer and wind blocks that save

heating energy in winter, provides habitat for species living in or moving through residential or industrial areas, and sequesters carbon that mitigates global warming.

### **Harvest of Undervalued Species**

Harvesting small diameter and undervalued species (e.g., scrub oak, red maple [*Acer rubrum*], ironwood [*Ostrya virginiana*], box elder [*Acer negundo*], black cherry [*Prunus serotina*]), nonnative honeysuckles (especially *Lonicera tatarica*, *L. morrowii*, and the hybrid *Lonicera x bella*), nonnative buckthorns (*Rhamnus cathartica* and *R. frangula*), and common prickly-ash (*Zanthoxylum americanum*) could help to create savanna and other important and desired semi-open habitats as well as to maintain more natural forest habitats. If new products and markets for these species and smaller trees (e.g., engineered wood products, wood composites, glued-laminated timber, wood fiber products, etc.) can be developed, it could benefit oak savanna and forest communities by creating more natural habitats especially if the harvested stands were the result of heavy grazing or high grading.

### **Large Block Management**

Maintaining habitats, whether they are forests or grasslands, in large contiguous blocks provides significant ecological and socioeconomic benefits. Managing habitats in large blocks can be more cost effective than working only with scattered small management units by consolidating planning activities and reducing travel costs. Whether it's large blocks of forest or grassland, a key is that at the appropriate (usually larger) scales, managers have a higher probability of working with viable populations rather than attempting to manage and maintain small, isolated populations that need periodic augmentation or other special attention. Large habitat blocks are more likely to accommodate natural or human-caused disturbances that will leave enough habitat relatively undisturbed so that species aren't lost due to the effects of that disturbance (e.g., fire, windstorm, or insect infestation). Conversely, various species or processes that require disturbances are more likely to be accommodated on large rather than small sites, other things being equal. Large blocks of forest or grassland can provide high-quality recreational experiences and contribute to higher wildlife and floristic diversity by accommodating area-sensitive species and other habitat specialists.

### **Harvesting Timber adjacent to and around Barrens Management Areas**

Harvesting timber from larger areas or aggregating sales could increase timber production efficiency and temporarily create "surrogate barrens" that could significantly benefit area-sensitive or dispersing barrens species. The key factors essential to taking advantage of this opportunity are integrated planning and managing the timing, scale, and location of timber harvest to create a shifting mosaic of extensive open habitats over time. The benefits of using natural regeneration techniques for jack

pine and creating habitats that are large enough to maintain area-sensitive species would also be important considerations and outcomes here. Many species could potentially benefit from such management scenarios, which could increase wildlife watching opportunities and associated revenues.

### **Establishment of Large Firebreaks in Fire Prone Areas**

Areas that are vulnerable to wildfire could be evaluated for both barrens restoration opportunities and the potential for the establishment of firebreaks that could reduce future risk of damage to life, property, and forest resources. This technique has been used in northwestern Wisconsin for many decades. Firebreaks are developed to protect forests and property. They are managed to keep canopy cover and tree densities low and when sited and configured properly can serve as corridors that link isolated barrens patches. Landowners can be educated in management strategies to protect their properties from fire. These strategies could initially result in increased timber harvest and provide a direct socioeconomic benefit to landowners in fire-prone areas.

### **Use of Fire as an Oak Management Tool**

Fire can be used to help regenerate oak-dominated natural communities and control competition from shrubs and other hardwood trees after harvest. This may be a cost effective way to regenerate commercially valuable oak trees while maintaining other components of the fire-adapted oak ecosystems. The use of prescribed fire can also benefit other fire-dependent forest communities, such as those dominated by pines, or mixtures of pines and oaks. In any of these cases, the reduction of fuel loads can lower the risk of uncontrollable wildfire.

### **Secondary Wood Processing**

An increase in local secondary wood processing could help support local economies and reduce transportation costs and energy use. Reduction in transportation costs for raw materials could help improve profits for businesses that produce secondary forest products and help the environment by reducing carbon emissions into the atmosphere.

### **Reforestation to Sequester Carbon**

Reforestation can be used as a potentially important tool to provide or increase needed habitats (especially those that have been diminished locally or regionally), increase product availability, and sequester carbon if done at meaningful scales, in the right places, and on the appropriate sites. One example would be to encourage reforestation in ecological landscapes that have lost much of their forest cover since Euro-American settlement. For example, the Central Lake Michigan Coastal Ecological Landscape was historically almost entirely forested but now has very little forest cover. Increasing the amount of forest, especially in areas such as major river corridors or the Lake Michigan shoreline, would provide habitat needed by migratory (and breeding) birds as

well as sequestering carbon. Places to avoid reforestation (or **afforestation**) are grassland and/or savanna management focus areas.

### **Land Use Planning**

Land use planning that encourages more compact residential and commercial land use can reduce habitat fragmentation and benefit forest interior and specialist species and forest recreational uses, while significantly reducing government and individual citizens' costs for public services (e.g., water, sewer, telephone, schools) and energy costs for transportation. Ecological planning on public lands can result in more successful and cost-effective management if the management is compatible with the ecology of the area (e.g., managing grasslands primarily in areas that were historically grasslands). In addition, if public lands management is planned at a broad scale, management can provide added benefits by increasing the amount of available habitat for area-sensitive species and ensuring that all species habitat needs are being met somewhere on the landscape.

### **Incentives**

Providing monetary incentives to create or maintain rare or needed habitats on private lands can provide needed habitat without the cost of buying the land and enlists the help of many private landowners. Landowners would benefit from the additional cash, wildlife would benefit from increased habitats, and the general public would benefit from improved environmental conditions. Examples of some current incentive programs include the Wisconsin Landowner Incentive Program (LIP), which offers landowner assistance to maintain rare communities such as savannas or prairies, the federal Conservation Reserve Program, and the federal **Wetland Reserve Program**. Other incentive programs that are needed include programs designed to maintain native grassland, savanna, and forest communities.

### **Increasing Recreation Lands**

The desire of many residents for amenity values from recreational lands near their homes can lead to creation of additional parks, nature preserves, greenways, and conservation easements. Adding protective buffer areas around existing undeveloped natural lands that are being impacted by heavy recreation use can help protect both the recreation services segment of the local economy and the area's ecological diversity.

### **Lakeshore Protection and Restoration**

Maintaining or restoring native shoreline and littoral zone vegetation can support more diverse plant and animal communities, reduce soil erosion and improve water quality, and help support native fish, amphibian, and invertebrate populations. When shorelines and associated habitats are abundant and in good condition, the need for stocking or other expensive means of accomplishing fish, wildlife, and water

management goals can be reduced. These actions would also maintain some of the amenities that initially attracted people to build homes in the area. Establishing natural areas on private lands and landscaping yards and shorelines with native vegetation could increase jobs and income for landscape contractors, native plant nurseries, and consultants while benefiting wildlife and more natural and compatible habitats.

### **Rehabilitation of Great Lakes Fisheries**

Rehabilitation and protection of naturally reproducing lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*), and other native fish populations will help support local commercial and sport fishing industries as well as restore a more balanced and self-sustaining aquatic ecosystem in Lake Superior. The need for stocking or other expensive means of maintaining fish populations will be reduced.

### **Protecting Stream Headwaters**

Protecting headwaters springs and spring runs and the upper watersheds of creeks can provide ecological and economic benefits by restoring, maintaining, and promoting high water quality and viable coldwater ecosystems in streams, especially within erosion-prone watersheds.

### **Protecting River Corridors**

Protecting large river corridors can provide significant ecological and economic benefits by restoring, maintaining, and promoting high water quality and good fishing opportunities and by providing habitat connections between southern and northern Wisconsin. These connected, continuous habitats serve as travel and dispersal corridors, provide habitat for plants and animals, and may become especially important as large-scale environmental changes (e.g., climate change) occur. An example would be the corridor of the Black River, which connects large blocks of public land in northern and southern Wisconsin. Other good examples include the Wolf, Wisconsin, Chippewa, St. Croix, and Mississippi river corridors.

### **Wetland Restoration**

Wetlands and shoreline vegetation with diverse, native vegetation would help maintain or improve water quality and potable groundwater and would reduce flood damage while potentially increasing habitat for many native plants and animals. Avoid creating conditions that favor the establishment of monotypic stands of invasive plants; they usually support habitat generalists and provide poor habitat for more specialized organisms or diverse species assemblages.

### **Stream Restoration**

Stream corridor restoration and management, including riparian wetland protection and restoration opportunities, enhances floodwater absorption, retention, and filtration while providing additional wildlife habitat and connectivity between habitats.

### Maintaining Rare Species and Communities

Preserving and restoring rare habitats such as natural communities limited to Great Lakes shoreline environments and their associated rare species (among which are a number of Great Lakes endemics occurring nowhere else in the world) and other natural communities known to support numerous rarities such as northern white-cedar swamps or fens can have socioeconomic as well as ecological benefits. Rare communities and species can be attractions to visitors, which provides an opportunity to educate people about these unique and often fragile features.

### Wildlife Viewing

Managing and restoring habitats that contain large numbers of wildlife species, or charismatic rare species (e.g., restoring wetlands to benefit cranes, geese, and swans) could increase ecotourism. This is especially true for sites that are close to metropolitan areas. Increased tourism can in turn benefit local restaurants, motels, and gas stations.

### Restoring Native Game Species

Restoring native fish and wildlife populations to appropriate locations and habitats that are fished or hunted (e.g., lake sturgeon or Wild Turkey [*Meleagris gallopavo*]) increases revenues from recreational fishing and hunting as well as provide habitat for some other native species. This management benefits the local economy through increased sales of food, gas, and lodging in the area.

### Quiet Sport Recreation

Maintaining natural areas, aesthetic areas, and trails for quiet sport recreation (such as mountain biking, skiing, hiking, camping, canoeing, kayaking) could have both ecological and



Wildlife viewing such as “birding” is one of the top recreational activities in Wisconsin and is compatible with many other uses. In 2006, trip-related and equipment-related expenditures associated with birding generated over \$82 billion in total industry output in the United States, including 671,000 jobs, and \$11 billion in local, state, and federal tax revenue. Further, birding participation in Wisconsin is reportedly above the national average (Carver 2009). Photo by Susan Schuller.

economic benefits. The local economy benefits from increased tourism, and natural communities and wildlife species benefit from the establishment of protected areas that may not be provided elsewhere.

### Birding Trails

The establishment of “birding trails” can guide those interested in wildlife viewing and appreciation, provide enjoyment and desired aesthetic experiences, help support local economies, create opportunities for education, and garner support for managing in ways that maintain species associated with regional ecosystems. The Great Wisconsin Birding and Nature Trail is established throughout Wisconsin with opportunities for bird and nature watching and attracting tourists and their dollars. Managing and restoring habitats that contain large numbers of wildlife species or rare species (e.g., restoring or maintaining wetlands to benefit Whooping Crane and geese or restoring or maintaining sedge meadows for their rare wildlife) increases ecotourism in the area.

### Biomass Energy Production

Use of forest residues (tops and limbs from timber harvesting or material from fuel reduction treatments) to produce energy could bolster the local economy and provide a renewable energy source. However, these practices should not be used where there are sandy soils. *Wisconsin's Forestland Woody Biomass Harvest Guidelines* (Herrick et al. 2009) should be consulted before any biomass harvest is considered. If forest residues such as small branches or bark, which contain large amounts of nutrients, are used for biomass, care must be taken to ensure that enough nutrients remain in the forest so that the activity is sustainable over the long term. Activities such as using sawdust and scrap wood materials from sawmills as an energy source for power production is a good example.

Growing trees specifically for biomass energy production (e.g., hybrid poplar) would need to be done in appropriate places (e.g., to connect other areas of woodland) and in a sustainable manner. This practice could benefit the local economy by providing additional forest crops and jobs and could benefit the environment by providing a renewable energy source and habitat for some species of wildlife. As this would be a new land use, the impacts need to be studied and policies established to minimize conflicts with other conservation efforts such as grassland and savanna management and other land uses, such as agriculture, and should be monitored to ensure that the practice is sustainable for the long term.

Growing switchgrass (*Panicum virgatum*) or other prairie grasses as a biofuel might be considered on agricultural lands on the ridge tops or valleys of some ecological landscapes. These could be grown on marginal farmland that is currently in agricultural production but is erosion-prone and poorly suited to row crop production. Growing perennial biomass crops on highly erodible farmland could result in additional grassland bird cover, reduced soil erosion, and better water quality while also providing income to farmers.

However, depending on the circumstances of the site, biofuel production should be evaluated to ensure that other benefits to grassland communities are not compromised.

### **Environmental Education**

There is excellent potential to reach a great number of people with various environmental messages. Impacts could run the gamut from public policy and law, to local and regional planning efforts, to designing curricula and conducting programs for students of diverse age groups and backgrounds who could assist in plant and animal surveys and participate in habitat management efforts. Programs featuring the “Arts” may also offer nature-based or nature-related programs and activities. It is also possible to receive professional training and earn advanced degrees in many fields related to the environment. Educational opportunities may increase awareness of the importance of a healthy natural world and its impact on enhancing social health. Large urban populations can drive the demand for additional public environmental quality programs and professional staff to manage them.

There is an opportunity to increase third through fifth grade student and teacher understanding and appreciation of Wisconsin’s native fish, wildlife, plants, and other natural resources. Educational opportunities for children should be included before reaching the third grade. Methods such as “teach the teacher” programs should be employed to further these educational efforts. A wildlife savvy population often supports sustainable wildlife management.

### **Native Landscaping**

Providing native landscaping and ecological restoration services (e.g., rain gardens and other water retention features) can benefit local economies as well as improve wildlife habitat, aesthetic beauty, and ecological functions (e.g., groundwater recharge).

### **Green Infrastructure**

There are opportunities to promote green infrastructure in heavily urbanized areas, including roof gardens, rain gardens, increasing the canopy of the urban forest, parking lot plantings and *pervious paving*, and low impact design. Opportunities also exist to partner with existing green programs in order to promote green infrastructure on public and private lands.

### **Manufacturing**

Use of sustainable manufacturing practices will not only increase profitability of companies in the long run but also improve the environment and quality of life for people.

### **Utilities**

Use of cleaner fuels and more advanced power generation techniques will improve the environment and long-term profitability for utility companies.

### **Transportation**

Improved public transportation can improve the aesthetic quality of an area by reducing auto pollution, road congestion, and petroleum use as well as attracting new industry in the future.

### **Agriculture**

Selling crops locally could benefit local residents by providing high quality food and reducing transportation costs. Numerous Community Supported Agriculture (CSA) farms, community gardens, and farmers’ markets could supply locally grown, fresh produce.

### **Water Conservation Programs**

Developing regional water conservation programs and other solutions to impending groundwater quantity problems needs to be integrated with protection of stream flows and lake recharge in order to protect the values of natural features that rely upon reliable and continuous groundwater inputs.

### **Remediation of Contaminants**

Removal of *polychlorinated biphenyls* (PCBs) and other contaminants and remediation of affected areas will help restore healthy fish and wildlife populations and provide clean, safe recreation for people of the area.

### **Brownfields**

*Brownfields* are abandoned or underused industrial and commercial facilities that can sometimes be restored to semi-natural habitat patches such as wetlands and grasslands to minimize storm water runoff pollution and provide opportunities for public recreation. Brownfields also offer opportunities for economic and environmental revitalization of central urban areas. Redevelopment of Brownfields and other sites (e.g., converting old or abandoned buildings to apartments or condominiums) can reduce sprawl and impacts on the rural environment. Grant funding is sometimes available from regional Wisconsin DNR offices as well as other government and nongovernment agencies and organizations.

For more details on the ecological and socioeconomic resources and management opportunities around the state, see the 16 individual ecological landscape chapters.

**Appendix 6.A. Scientific names of species mentioned in the text.**

Common name	Scientific name
American beech	<i>Fagus grandifolia</i>
Bald Eagle <sup>a</sup>	<i>Haliaeetus leucocephalus</i>
Balsam fir	<i>Abies balsamea</i>
Big brown bat	<i>Eptesicus fuscus</i>
Black ash	<i>Fraxinus nigra</i>
Black bear	<i>Ursus americanus</i>
Black cherry	<i>Prunus serotina</i>
Black oak	<i>Quercus velutina</i>
Black spruce	<i>Picea mariana</i>
Bobcat	<i>Lynx rufus</i>
Box elder	<i>Acer negundo</i>
Canada Warbler	<i>Cardellina canadensis</i> , listed as <i>Wilsonia canadensis</i> on the Wisconsin Natural Heritage Working List
Canvasback	<i>Aythya valisineria</i>
Common Loon	<i>Gavia immer</i>
Common prickly-ash	<i>Zanthoxylum americanum</i>
Common reed	<i>Phragmites australis</i>
Connecticut Warbler	<i>Oporornis agilis</i>
Eastern hemlock	<i>Tsuga canadensis</i>
Eastern pipistrelle	<i>Perimyotis subflavus</i>
Eastern red-cedar	<i>Juniperus virginiana</i>
Eastern white pine	<i>Pinus strobus</i>
Eurasian buckthorns	<i>Rhamnus cathartica</i> and <i>R. frangula</i>
Eurasian honeysuckles	<i>Lonicera tatarica</i> , <i>L. morrowii</i> , and <i>Lonicera x bella</i>
Gray wolf	<i>Canis lupus</i>
Greater Prairie-chicken	<i>Tympanuchus cupido</i>
Ironwood	<i>Ostrya virginiana</i>
Jack pine	<i>Pinus banksiana</i>
Karner blue butterfly	<i>Lycaeides melissa samuelis</i>
Kirtland's Warbler	<i>Setophaga kirtlandii</i> , listed as <i>Dendroica kirtlandii</i> on the Wisconsin Natural Heritage Working List
Lake trout	<i>Salvelinus namaycush</i>
Lake sturgeon	<i>Acipenser fulvescens</i>
Lake whitefish	<i>Coregonus clupeaformis</i>
Little brown bat	<i>Myotis lucifugus</i>
Lupine	<i>Lupinus Perennis</i>
Moose	<i>Alces alces</i>
Muskellunge	<i>Esox masquinongy</i>
Northern Harrier	<i>Circus cyaneus</i>
Northern long-eared bat	<i>Myotis septentrionalis</i>
Northern pin oak	<i>Quercus ellipsoidalis</i>
Northern red oak	<i>Quercus rubra</i>
Northern white-cedar	<i>Thuja occidentalis</i>
Osprey	<i>Pandion haliaetus</i>
Quaking aspen	<i>Populus tremuloides</i>
Red Crossbill	<i>Loxia curvirostra</i>
Red maple	<i>Acer rubrum</i>
Red pine	<i>Pinus resinosa</i>
Sharp-tailed Grouse	<i>Tympanuchus phasianellus</i>
Short-eared Owl	<i>Asio flammeus</i>
Switchgrass	<i>Panicum virgatum</i>
Tamarack	<i>Larix laricina</i>
Trumpeter Swan	<i>Cygnus buccinator</i>
Tundra Swan	<i>Cygnus columbianus</i>
Upland Sandpiper	<i>Bartramia longicauda</i>
Walleye	<i>Sander vitreus</i>
White birch	<i>Betula papyrifera</i>
White-nose fungus	<i>Geomyces destructans</i>
White spruce	<i>Picea glauca</i>
White-tailed deer	<i>Odocoileus virginianus</i>
Whooping Crane	<i>Grus americana</i>
Wild lupine	<i>Lupinus perennis</i>
Wild Turkey	<i>Meleagris gallopavo</i>
Yellow birch	<i>Betula alleghaniensis</i>

<sup>a</sup>The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

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